THE ARCHITECTURE

OF

THE HEAVENS.

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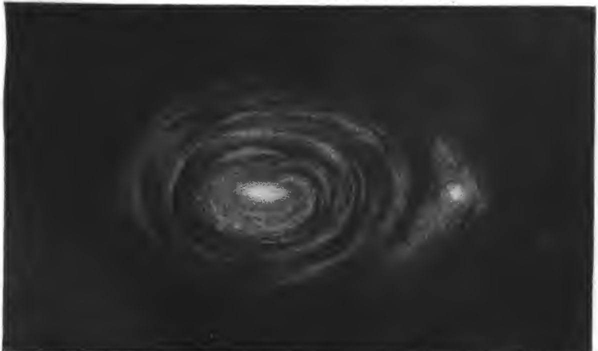
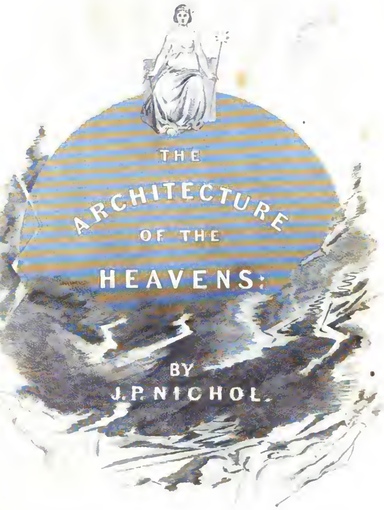
FRONTISPIECE





JOHN W. PARKER WEST STRAND

LONDON

MDCCCL.

TO THE RIGHT HON.

THE COUNTESS OF ROSSE,

THIS VOLUME,

RELATING TO A HIGH AND ARDUOUS SUBJECT,

WHICH HAS DERIVED A GREAT EXPANSION

AND ITS NEWEST INTEREST

FROM THE LABOURS OF HER ILLUSTRIOUS HUSBAND

IS RESPECTFULLY INSCRIBED.

JAN. 1, 1850.

PLATE I

seeking & sou[illegible]
And raised by thought

PREFACE.

THE volume now published bears the name of one which has received a large and, I fear, an unmerited share of the public favour. But as the condition of existing knowledge regarding the grander celestial phenomena, is very different from what it was in the year 1838, when I wrote the *Architecture of the Heavens*, I have produced a new work, although retaining the former title.

Since the date of that early publication, a fresh era in respect of telescopic power, has supervened. The magnificent and most exact instruments of Parsonstown have converted what was twilight into daylight, and penetrated into regions of space formerly enveloped in utter darkness: for—as always follows on events so auspicious—not only has the vague and uncertain been trans-

formed into what is distinct; but, by obtaining for us a large and invaluable addition to the list of established or indubitable facts, these recent researches have likewise corrected our manner of judging respecting appearances, around which—because of their excessive remoteness or evanescence—doubt continues to remain.

I shall not attempt to state in this place—with whatever brevity—the changes which distinguish my present work from its predecessor in name. These—great and small—the reader will easily detect: but I am bound, at the earliest opportunity, to record, that unless for the remarkable kindness of Lord Rosse, I would not have written this volume now. The labour to which his Lordship has devoted himself—that of measuring micrometrically the extraordinary nebular forms disclosed by his great mirrors—cannot be completed unless after the lapse of a period commensurate with its unparalleled extent and rare importance; but this consideration has not withheld him from permitting me to employ as many of the drawings already in his Observation-Books as appeared sufficient to render the character of his recent discoveries generally understood. I do not, I

presume, require to inform my reader, that the figures now placed before him, are simply transcripts by the eye, of the object as it appears in the field of the telescope; but, although subsequent observation may induce the alteration of minute features, and determine with greater nicety their proportional magnitudes and degrees of illumination, I cannot consider that any thing is wanting in these sketches, even as they are, in reference to the purpose I have in view,—that, viz., of exposing, in broad outline, the peculiarity of the course along which investigation seems at present promising to pass.—The most striking characteristic of this modern Age is its unresting activity, and the rapidity of its transitions; and astronomical discovery and speculation, have partaken of the universal instability so eminently, that the records of the last few years contain trophies which in former times would have constituted the rich distinction of a century. The revolution of our views regarding the larger sidereal arrangements has, indeed, been so signal, and the prospects before us are so unwonted, that it were inexcusable at the present moment to adventure dogmatically on any attempt to *systematize*, or even

to expose facts under the form of system, unless with the desire to give strongest expression to the *relations* which already appear.

The general intent of my volume corresponds with that of its predecessor. I have not restricted myself to an account of any special class of facts or discoveries, but endeavoured to offer a sketch, more or less complete, of all our knowledge regarding the arrangements and relations of the fixed stars: inasmuch, however, as the general intelligence concerning subjects of this nature is much higher than it was in 1838, I have not conceived it requisite to refrain so carefully as I did then, from assuming that certain elementary considerations are not familiar to my readers. Nevertheless, it is my expectation that any one perusing these pages with the care due to a subject so high and elevating, will not fail—should the endeavour be sincere—to appropriate a knowledge of all of chief importance, hitherto ascertained concerning these noblest forms of the material creation.

This reproduction of the *Architecture of the Heavens* is distinguished by another feature—to which, however, I cannot refer, unaffected by a painful melancholy. Having determined, with a view to do full justice to the engravings, not to confine myself within the size of page I had formerly adopted, I entertained the idea of farther adorning my volume according to the fashion of the time: and the late David Scott—one of the finest and most thoughtful geniuses of whom this Northern portion of our Island can boast—gladly consented to describe, by his extraordinary pencil, some of the emotions and aspirations produced in him by the loftier speculations of Astronomy. Alas! the gifted painter died ere his labour of love was finished; but I have been enabled, through the kindness and with the co-operation of his brother, to associate

with this completion of my task, a number of designs which would be the ornament of any work, and whose remarkable character vividly recals some of the best features of the heart and powers of Mr. Scott. Passing, however, from everything like disquisition on productions so singular, or rather referring to a few remarks on a subsequent page, I would here simply request of any one, who on merely opening my volume at a page presenting one of these sketches, may fancy that, as a *Critic*, he could detect traces of peculiarities that have sometimes been charged against the smaller productions of this most original Artist,—that he rather turn, as an *Inquirer*, to the IDEA of the sketch, to its elevation and exuberant power, as well as to the wonderful energy and fulness with which it is wrought out: for then I feel assured he will unite with me in deploring, that these are the last utterances of a Spirit whom the world can ill spare from among her too few teachers concerning Truth and Beauty and Holiness. In distributing the designs through my volume, I have generally placed at the beginning of a chapter, that one which seemed most accordant with the feelings I would desire

that the study of the chapter leave behind it. This is an association very hazardous for me. In proportion as my reader acknowledges a congruity, shall I estimate my own success; even as in every effort as an Instructor, I could long for the resolution—the unswerving aim, and unsullied purity of my departed Friend.

Observatory, Glasgow,
1st Jan. 1850.

THE PLATES.

I.

The sketches of astronomical subjects in the following volume, require certain preliminary explanation. Of the representations of actual nebulæ, there are, from the great telescopes of Parsonstown, the Frontispiece and nine Plates—viz., Plates V., VII., VIII., X., XI., XII., XIII., XV., and XVI. These, as already indicated, are eye-sketches only—*i.e.* the different parts of them are merely placed by the eye in their apparent relative positions, just as one does with the various features of a landscape when sketching it; but it is Lord Rosse's practice to make independent drawings of each object on different nights, and subsequently to compare them; and the forms I now present, are the result, in each case, of such comparisons. They may thus be considered the first step towards those finished or geometrically accurate drawings, which careful measurements of the different parts of each figure, are required to produce. The only serious error to which such preliminary sketches are likely to be liable, has reference to their *relative size;* as in estimating difference of size at remote intervals of time, even in a field of uniform dimension, the eye is always liable to mistake; and for this reason no *precise*

account has been taken of the comparative magnitudes of the various objects, in the manner in which they are produced here. There is a general consistency, perhaps, in this respect likewise; but I have chiefly desired to represent each object with the distinctness due to the peculiarities of its own form; and in so far as these are concerned—viz., the proportion, size, and arrangement of the component parts of each sketch—the difference between the draft now presented and the finished drawing, will probably be scarcely perceptible to the general observer. Similar remarks, as to relative size, &c., apply to all the other Plates; the great Nebula of ORION, for instance, or that of ANDROMEDA, must be regarded apart—as individual representations; and for all necessary information regarding their relative importance amid the general system of the heavens, the reader must look to the text of my volume.—I cannot omit recording my high satisfaction with the manner in which the engraver, Mr. RANDAL DALE, has executed his work. The drawings at Parsonstown—as indeed, almost always at observatories, —reverse the light and shade—*i. e.*, the nebula appears dark on a white ground; so that Mr. DALE has required to reverse again from the copy, in order to produce an approximation to the effect of the actual object. And in general, this part of the task, has been executed with as great success, as he has attained in his endeavour to secure beauty of execution.—The following tables indi-

cate the places of the least known nebulæ in the heavens, as well as the distribution of all the plates through the volume.

DISTRIBUTION OF ASTRONOMICAL PLATES.

POSITIONS OF NEBULÆ IN THE SKY.

I. CLUSTER IN HERCULES		R. A.	$16^h\ 36^m$
		N.P.D.	$53^\circ\ 13'$
II. CLUSTER OF PLATE V.		R. A.	$21^h\ 25^m$
		N.P.D.	$91^\circ\ 34'$
III. CRAB NEBULA		R. A.	$5^h\ 24^m$
		N.P.D.	$68^\circ\ 7'$
IV. DUMB BELL NEBULA		R. A.	$19^h\ 52^m$
		N.P.D.	$67^\circ\ 44'$
V. NEBULÆ WITH HOLLOW CENTRES	1	R. A.	$18^h\ 47^m$
		N.P.D.	$57^\circ\ 11'$
	2	R. A.	$11^h\ 6^m$
		N.P.D.	$34^\circ\ 10'$
VI. OBLIQUE ANNULUS		R. A.	$15^h\ 39^m$
		N.P.D.	$33^\circ\ 39'$
VII. GREAT SPIRAL		R. A.	$13^h\ 22\frac{1}{2}^m$
		N.P.D.	$43^\circ\ 46'$
VIII. CIRCULAR SPIRAL		R. A.	$9^h\ 23^m$
		N.P.D.	$67^\circ\ 45'$
IX. OPEN SPIRAL		R. A.	$12^h\ 10^m$
		N.P.D.	$74^\circ\ 38'$
X. SPIRAL SEEN OBLIQUELY		R. A.	$11^h\ 10^m$
		N.P.D.	$75^\circ\ 59'$
XI. CLUSTER OF SMALL NEBULÆ		R. A.	$0^h\ 57^m$
		N.P.D.	$58^\circ\ 27'$

II.

The poetic or symbolical illustrations—the latest gleamings of SCOTT's daring and peculiar genius—would, had this remarkable artist been longer spared to humanity, have probably been etched by himself. As it is, I was fortunate enough to secure the aid of his brother, Mr. WILLIAM B. SCOTT, who has engraved the most characteristic of them; and other assistance has permitted me to present the greater part of what remained, of the original series.

These singular works, as well as other productions of Mr. SCOTT's, of a like kind, ought, I think, to show the world what unknown but not inaccessible spheres there exist, for the developments of high art, in connexion with other mighty subjects than either the Greek Mythology or Roman-catholic Christianity. As specimens of design, they are surely very wonderful; and if the drawing of the figures appears anywhere somewhat uncommon, it must be kept in mind that each and all of those images are purely *symbolical* personages. That which distinguishes this set of illus-

trations, however, is the amazing wealth of thought which they contain.

Let us turn, for example, to the family group among the stars. At first sight, it may be no more to the eye and mind of the student, than a graceful enough representation of an ordinary scene. But let him contemplate it a little longer, and the fulness of its meaning will gradually break upon his heart. Does he remember an aphorism in Coleridge's 'Aids to Reflection, concerning the emotional history of human knowledge'? 'Knowledge,' says he, 'begins in wonder, but it ends in amazement, while admiration fills up the interspace. The first wonder is the offspring of ignorance, the last is the parent of adoration. The first is the birth-throe of our knowledge; the last is its euthanasia or apotheosis.' Such is the solemn text taken from Plato, and beautified by the English philosopher, which this design repeats in the peculiar language of the art to which it belongs. The eager boy, the timid girl, hold by the mother's hands, and press to her side, while they *peer* with young wonder and young fear into the depths of starry space. The boy is all eye; his soul drinks in the crescent moon and her thousand stars, and he is afraid as well as overjoyed. The girl is like him, yet different. They stand for the expression of the *first* wonder, the wonder of

nescience, the 'birth-throe of knowledge.' The father, a shepherd with his crook, sits before them on the ground, has a rude instrument by his side, is resting from the labour of life, and looks upon the midnight sky, with confidence and calm. He lives in the interspace of admiration, nowise alarmed on the one hand, and nowise lifted out of himself on the other. But the mother, the fully-developed religious and poetic element of human nature, stands erect as the statue of a Goddess. Her look pierces beyond the starry frame. It is merely a splendid veil to her eye, and she sees through it into the central wonder. Her spirit has passed through the heavens into the immediate presence of God; and she represents the euthanasy of astronomical—nay, of all scientific exploration.

Yet this particular design is one of the least profoundly and largely significant of the series; and it is for that reason it has been chosen for special explanation. Let the reader follow the clue now given when he studies the remainder of these illustrations; and he will not lose his reward, if it be beneficial to have one's scientific reflections and philosophical conclusions, bathed in the mellow light of beauty.

I would more particularly call his attention to the 'procession of thoughts from the Infinite, before the inward eye of the Discoverer,' with its mysterious and

spiritual dignity: to the gracious suavity of 'Man elevated by thought:' to the pure enthusiasm of the 'Astronomer and his ideal auditory:' and to the almost intolerable rapture of the 'Soul listening to the eternal melodies.' It is unnecessary to add more. It would even be wrong to do so; for the great pleasure and the great profit to be derived from such labours of the imagination of a great Artist, consist in the very act or process by which they steal into the soul, and spontaneously shed their manifold signification—like the mingled flowers, fruits, and leaves of an early autumn.

DISTRIBUTION OF MR. SCOTT'S PLATES.

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ERRATA.

In page 81, third line from top, for *rests* read *resting.*

— 82, sixth line from the bottom, instead of *tidal movements of the ocean,* read *oblate figure of the planets.*

— 97, line 10, read *accumulations.*

— 185, line 2, for *on* read *or.*

— 217, line 13, for *power* read *powers.*

— 218, line 11, for *as my belief* read *as is my belief.*

PART I.

GALILEO, OR APPREHENSION.

PLATE III.

In wonder all philosophy begins, in wonder it ends, while Admiration fills up the interspace but the first wonder is The offspring of ignorance, the last is the parent of adoration The first is the birth-throe of knowledge, and the last is its Euthanasia or apotheosis

CHAPTER I.

ASPECTS AND GENERAL STRUCTURE OF THE HEAVENS.

IT is not easy for one of the present time, to appreciate or estimate aright the extent of what is due to science, even in our current interpretations of the phenomena of the heavens. Nurtured from infancy amid certain great conceptions—viz., that the stars are suns strewn in myriads throughout space, and that the world from which we gaze on them is only a secondary globe, a dependent on one of their mighty throng, we are often nigh to forgetting, that, to the natural eye, nothing is revealed by the superincumbent vault, except an array of sparkling points, occupying the midnight with their unspeakable beauty, most of them apart and alone, but sometimes grouped into graceful clusters; while across the wonderful fields they adorn, something like a stream of subdued, indefinite light, irregularly wanders. Exquisite, indeed, the outward spectacle; nor has it failed ever to move and purify our human heart, speaking through its stillness and unstained splendour, of ORDER lofty though remote, and of regions that are always

serene; but assuredly, of all others that effort is most memorable, which has penetrated beyond this sensuous beholding, which sustains us through depths to which these visible skies are but a portal, and can discern among their profounder recesses the presence of a living Spirit, filling even Infinitude with material forms—intelligible symbols of His purposes and glory.

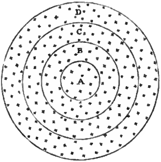
A change of view so remarkable having been accomplished—viz., the transition from a rude but natural appreciation of celestial appearances, to conceptions with which Reason in later days has rendered us familiar,—it is fortunately not difficult to explain the processes of thought which slowly, and with toil, have led to it; just as one who, through severe labour, has attained some virgin elevation, can frequently indicate a less arduous track to those who afterwards would attempt the ascent. The truth which must here be considered fundamental, and which first must become a fixed and determinate possession in the mind, is indeed by no means an abstruse one—being a general proposition regarding the *comparative distances* of the stars. It is, certainly, not to be pretended, that, prior to these recent times, any proposition connected with such distances could allege for itself a basis in positive measurement; for to modern Art and the unrivalled delicacy of its instruments we owe our whole power of carrying among

the spaces of the fixed stars, the precise tape of the surveyor, and dividing their intervals by milestones: but, apart from such definite achievements, there are a few hypotheses of easy apprehension, and whose adoption is justified by the agreement of their consequences with extensive classes of established facts, that suffice—at least as a torch—to preserve us from erring amid the twilight, and reveal the existence and general form of remote objects, whose precise outlines still are indistinct—obscured by the onward shades. We shall reach these hypotheses on critically examining the phenomena of the *apparent magnitudes* of the stars.

I. On the most cursory glance at the heavens, we discern that the orbs they contain are endued with many varieties of splendour. Descending from those superb bodies which we term of the first magnitude, they fade through every degree, down towards absolute invisibility; and if the eye be armed with a telescope, new multitudes are discovered, which also diminish until a farther limit of minuteness is reached, again concealing all below it, even from that keener vision. Now, the question naturally suggested by such a spectacle is—whether these varieties are *real*, or *apparent* only?—whether they betoken positive differences in the magnitudes of the stars, or, rather, a fact of much more importance—viz., that the orbs are placed at very *different distances* from

the earth? It is, indeed, now undeniable, that the shining hosts above us, are not of one uniform magnitude. Certain comparatively small stars, for instance, whose distances have been measured, are not inconceivably remote from our planetary system; while some of the most splendid bodies in the sky, are immersed so profoundly within space, that with all the consummate powers and ingenuity of art, we can yet do nothing more than assign a *limit*, nearer than which they certainly do not lie. Among those beautiful collocations too, that are termed *multiple stars*, there are many examples of bodies closely associated, forming units of one remarkable though not extensive mechanism, which—as they have different apparent brightnesses—must emit actually various amounts of light. But whatever the bearing of such indications, it were erroneous to deem the point now at issue, determined by them; for the question is not, whether among these innumerable orbs there is no real variation of size; but whether the endless diversities of apparent magnitude, result from differences such as I have specified; or whether—notwithstanding the existence of actual irregularities—that phenomenon does not expressly indicate the manner in which the stars are distributed through space? The problem may at first seem difficult, if not insoluble; but it is easy to imagine circumstances which, even in the absence of actual admeasurements, would go far to deliver it from obscurity.

If, for instance, our world had been placed in the centre of a congeries of stars *scattered uniformly* among the surrounding spaces, we should certainly have found—had the orbs been of the same actual size—not merely the existence of different apparent magnitudes descending to the point of invisibility, but the numbers belonging to the different orders increasing in *a determinate manner*, according as their apparent lustre diminished. Suppose *A* the position of our earth or sun, and the circle nearest it the limit of the sphere of stars of the first magnitude,



while the rings *B*, *C*, *D*, &c. constitute in the same manner the spheres of stars of the second, third, fourth, &c. orders; I presume it is manifest, that, as the sizes or *capacities* of these spheres or *rings*, bear among each other, definite and fixed *relations*, so would the *numbers* of the luminaries distributed uniformly through them:

and if, on counting up the stars of such a system, when accurately distributed into orders, one found a precise correspondence between these observed numbers and the capacities of the spheres respectively assigned them by our hypothesis,—could doubt remain as to the truth of that hypothesis—would we reject the conclusion that these varying apparent magnitudes indicate different degrees of remoteness in space? Nay, even were the correspondence between the two sets of quantities—the numbers furnished by our stellar catalogues, and those indicating the capacities of the several spheres—not absolutely precise, but only approximate; we should still, if the approximation were close, not be disposed thereby to abandon our inference, but rather to conclude that *minor irregularities* exist, and hinder a perfect or mathematical equality. One source of such incongruity might indeed be, those actual variations in size which are certainly found among the stars; but unless such positive differences had *as many degrees* as the apparent ones, or had influenced the principle governing the distribution of the stars, they would *disturb* only, or in so far impair the exactness of the expected correspondences; and our argument would still continue, possessed of the remarkable force always springing from a proximate equality among numbers so very large, and whose origins are independent. In no portion of the finite universe, need we expect absolute or unvaried uniformity. One law

or principle never operates wholly unaffected by others; so that visible phenomena are always results of various intermingling causes: but there is little hazard, in at any time inferring the predominant or governing influence of some one principle, if — across all modifications — its effects stand out clear and undisguised.

II. The actual structure of our heavens, however, is not so simple as in the case I have supposed. The unaided eye informs us that there is no regular distribution of stars among these environing spaces; for, while some regions of the sky are comparatively faint, others burn with a surpassing splendour. At first sight, it therefore might appear that arguments like those I have used, cannot be applied to actual phenomena; for they rest on the hypothesis that these brilliant bodies are strewn around with some approach to uniformity. Unless on the ground of some such maxim, we clearly could not calculate the probable number of stars belonging to any of the spheres A, B, C, D, &c., (page 5;) nor is it easy to discern with what practical avail any other computation could be made. But on closer inspection, a difficulty seemingly insuperable, in a great measure disappears. The irregularity of distribution in the sky, is nowhere found, so long as we confine our regards to *any one direction*, but only comes into view when we compare what is observed along *different directions*. For instance: the stars that

are visible when we look *northwards*, present no relation to the numbers in view when we look *eastwards;* but on scrutinizing the phenomena *along either line*, the remarkable fact reappears, that the numbers of the various orders correspond approximately with what would certainly exist, if comparative magnitude were the effect of comparative distance. In Plate III. (page 24) I have reproduced a chart imagined by M. STRUVE, which will be found instructive here. The astronomer had collected from our best catalogues all the stars lying near the Equator, in every portion of the circuit of the heavens, down to those of the ninth magnitude; and after arranging them into *orders of brightness*, he has disposed them on his chart, in general conformity with these orders, but with especial provision that *each class or order should occupy a sphere proportionate to its numbers.* The distances accurately fixed in accordance with this latter principle, are indicated on the line outside the plate; and they scarcely differ — certainly nowhere seriously — from what might have been inferred from consideration of the various degrees of brilliancy alone. Observe, too, the singular regularity of the chart, along any line from centre to circumference; a regularity in nowise conceivable, had the principle of its construction been largely in error. If my reader has been accustomed to deal with probabilities; to judge of vast problems, regarding which

we must weigh and balance instead of demonstrate, —assuredly he will permit me now to assume it as established by the main aspects of the heavens, that according as their apparent magnitudes diminish, we may infer the increasing remotenesses of the stars. In regard of our grander conclusions, dependence on this maxim will never deceive; and for whatever may seem to be incongruous, we shall find, farther onwards, an explanation, in limited varieties of actual magnitude, and intrinsic splendour, as well as in certain peculiarities in the distribution of the stars, chiefly recognised about the outer limits of the telescope's reach—guiding us to further and more memorable disclosures concerning the plan of the universe.

Truths of the character of the foregoing can rarely be invested with the highest degree of evidence, or appear as absolute *certainties;* but lest our apprehension of the *nature* of the truth in this instance should seem affected by whatever of vagueness may appear to environ its foundations, I shall dwell a little longer on its details, as they are seen in the skies. Though apparently late in date, no victory of modern practical science can be esteemed more signal than that, which so recently has enabled us to compute accurately the distances of several of the stars. The difficulty lay in the exceeding remoteness of these bodies—a remoteness that seemed

immeasurable by any *unit* or fixed distance furnished by the phenomena of our world. The largest definite line, of which, for such a purpose, man can have command, is the radius of the earth's orbit, or our distance from the sun—in round numbers, one hundred millions of miles; and yet the average distance of the first or most brilliant order of stars is nearly one million of times as large! Notwithstanding, however, the apparent impracticability of the problem, it has been solved in the case of nearly forty distinct bodies; from whose distances we now gather the correct position of the spheres proper to bodies of the first and second magnitudes; and analogy, guided by the considerations which influenced M. Struve, enables one to infer, within a close approximation, the remoteness of the rest. By the subjoined Table, my readers will be assisted to definite ideas on this astonishing subject; and a brief reflection on its significance must avail more than prolonged description. It is intended to exhibit the remotenesses of the several spheres *within* which, stars of the different orders must all respectively lie; and, lest the numbers referring their distances to that immense unit—the radius of the earth's path around the sun, should themselves, because of their magnitude, be found also inconceivable; I have introduced in the third column a yet higher standard of comparison—the highest, indeed, with which physical inquiry has

furnished us — viz., the almost magical velocity of light.

DISTANCES OF THE VARIOUS ORDERS OF STARS FROM OUR SOLAR SPHERE.

Apparent Magnitudes.	Distances of the exterior Limit of the various Orders, expressed in radii of the Earth's orbit.	Number of Years occupied by light in traversing those distances.
1	1,246,000	19.6
2	2,111,000	33.3
3	3,151,000	49.7
4	4,375,000	69.0
5	6,121,000	96.6
6	8,746,000	137.9
7	14,230,000	224.5
8	24,490,000	386.3
9	37,200,000	586.7

What a scene is thus opened! How august now these majesties of Night! The boundary of unaided vision is the sphere of stars of the *sixth* magnitude— that inner small circle of the chart of M. STRUVE: those numberless points, scarce perceptible, twinkling so faintly on the surface of darkness, are thus so remote, that the light which now arrives at our world quitted their surfaces nearly one hundred and forty years ago! But profounder than this limit of natural vision—

beyond even the reach of the Poulkova telescope—look into those onward depths. In the Milky Way, thronged all over with splendour, there is one portion not unnoticed by the general observer—the spot in the sword-handle of Perseus: that spot shows no stars to the Eye; the milky light radiates from beyond our reach. To a telescope of considerable power, the space appears lighted up with unnumbered orbs, as shown in Plate I.; and these pass on and on, through space's depths, until, even to that penetrating glance, they escape all scrutiny, withdrawing into regions unvisited by its power. Shall we adventure into these deeper retirements? Then assume an instrument of higher efficacy, and lo! the scene is only repeated—the nearer stars now shine more brilliantly; those scarce observed before, appear as large orbs; and behind, a new series begins, again shading gradually away, leading towards farther mysteries! The illustrious HERSCHEL penetrated, on one occasion, into this spot, until he found himself among depths, whose light could not have reached him in much less than four thousand years: no marvel that then he withdrew from the pursuit, conceiving that such abysses must be endless!

Plate I

So soon as the truths I have exposed become realities in the mind, they give birth to adequate conceptions of the grandeur of the Object engaging us. In the midst of myriads of orbs, assuredly majestic as our sun, strewn through depths in whose presence the loftiest imagination must sink down bewildered and appalled,—we are to inquire, what is to be learned concerning the arrangements of these stars—the grand *system* which they constitute in space? That a problem so strange and adventurous never was suggested until the dawn of these present times, cannot be deemed remarkable; for when man had attained to knowledge which shrivelled his sun and all its worlds into the veriest point, what wonder though he felt as if an absolute boundary had been reached—the limit at which reason must give place to awe? But the close of last century was distinguished by two events, which could not occur together without ensuring unexpected advancement.

The TELESCOPE, formerly of feeble range, suddenly assumed a capability of sounding profundities wholly inaccessible before; and the Man in whose hands it took on this new efficiency was possessed of a genius to which all opportunities could be entrusted, for it was equal to the highest. The rise of Sir WILLIAM HERSCHEL marks the first and still the greatest epoch of the modern astronomy. He was struck for a discoverer in the finest mould. Mingling boldness, with a just modesty, a thirsting after large and general views, with a peculiar sensitiveness in regard to *existing* analogies, and a habit of scrupulous and dutiful obedience to their intimations, he was precisely the man first to quit paths which, through familiarity, were common and safe, and to guide us into regions, dim and remote, where the mind, as a lamp to itself, must walk entirely by lights which stream from internal fountains.

There is one infallible mark of the rise of an original mind. When one sees a man in the midst of his contemporaries, not contesting opinions, not quarrelling, but quietly, and without either ostentation or fear, proceeding to resolve by reason subjects which had hitherto been in possession of 'common belief,' it is certain that a signal access of knowledge is awaiting us; for the freshest stamp of Divinity is upon that man. In HERSCHEL's first remarkable paper on the *Construction of the Heavens*,

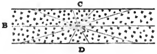
there is alike abundant evidence of this especial daring and sure presages of his fame: without difficulty or pretence, he there casts aside an idea which had not been questioned before, unless in a few of those obscure, indefinite speculations, which, strangely enough, often prelude important discoveries. It seems to have been fancied, prior to the systematic inquiries of this great astronomer, that the sky, as we see it, is infinite; or that stars, in collocation similar to what meets our eye, stretch outwards through all space; but the justice of this conclusion is impugned by the existence of a MILKY WAY manifested as ours. Had our planetary system occupied a place within some unlimited, and therefore formless bed of stars, we would most probably have possessed a Milky Way, of greater or less brilliancy, as a *background of the whole heavens;* for multitudes of stars, invisible by any increase of power derivable from artificial contrivances, must then have lain in every direction; and, from the intermingling of their rays, an illumination would probably have proceeded, sufficient to efface absolute darkness. Such an illumination, however, being descried only along one splendid but comparatively narrow zone, spanning the sky almost as a great circle of the sphere; does it not seem, even at first sight, that, *only in the direction of that zone,* do the orbs around us stretch outwards in countless multitudes—that there alone are our heavens of an *immeasurable depth?* The conception is,

indeed, an extraordinary one; but once again, look thoughtfully on the face of the Night. All regions of the sky are assuredly full of these stellar glories; but if one compares the superb belt of the Milky Way with spaces at the side of it, how faint are these, and how dazzling the former! Nay, does it sound surprising that through *its depths alone*, can the telescope wander without fearing any end to discovery; and that when directed elsewhere, farther stars begin as if to hesitate to appear even at its most potent invocations? Singular though it be, the idea speedily commends itself, that along the dazzling circuit of this zone, our stellar heavens must have depths far more profound than those of other regions; so that, almost unwittingly, we become inclined to connect the conception of SHAPE with that scheme of orbs which men still generally regard as the most august material emblem of the INFINITE.

I intend, for the most part, to follow HERSCHEL in farther elucidating the truth now presented, as I shall suppose, for the first time, for my reader's acceptance. Let us think of the appearances which would be noticed by an observant man, as characteristic of his position, if he were in the midst of a forest, infinite or very extensive. In his immediate vicinity the surrounding trees would be well defined, and of the largest proportion; behind these, he would see another range, smaller, but

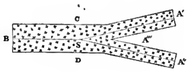
also well defined; and so on through many gradations of size and distinctness, until individual trees could no longer be distinguished, and the view terminated in an unnamed and vague appearance, which I may be permitted to call a diffused *woodiness*. But if this peculiar background were not seen in every direction—the light of the sky appearing through the trees in different places—the conclusion would be just and manifest, that the forest has not the characteristics of one stretching out indefinitely, or even equally, on all sides—that in some directions its edges are nearer than in others, or that it is merely a group of trees, having boundaries, and of a particular and ascertainable shape. Now, recollecting, in the case of the heavens, that on looking around any one of its circuits, it is only *at two opposite points* that the perspective melts into this diffused *milkiness*, is not the opinion forced on us, that we are placed amid what is merely a group or cluster of stars of peculiar configuration,—any section of which must be greatly elongated in the direction of the Milky Way? A simple diagram will explain how existing appearances are, at all events, roughly accounted for by this hypothesis; and the same illustration indicates the chief modifications required, to bring it into a perfect and minute consistency with every characteristic of the skies. If a spectator were placed in a world, *S*, in the midst of a stratum or bed of stars, bounded, as beneath,

by the lines *C* and *D*, *i. e.*, narrow, or, at least, measurable in breadth, as in the directions *S C*, *S D*,



but indefinitely prolonged towards *A* and *B;* he would manifestly be engirt by heavens having the general aspect of ours: for, on looking along any line, from *S* towards *C* or *D*, he might see *through* the cluster, and the regions in that quarter would, therefore, all appear as a comparatively dark ground, bespangled with multitudes of distinguishable luminaries; while in the directions *S A* and *S B*, before and behind, his eyes would fail, as ours do when turned to the Milky Way, in separating the individual bodies, or in recognising the existence of the remoter masses, otherwise than in the silvery twilight coming from their aggregation. If our Milky Way were a simple continuous belt, I think it evinced by these considerations, that all the more prominent phenomena of the sky could be explained by the supposition that we are in the midst of *an oblong stratum* of stars of a certain regularity: but our zone is not *simple* as supposed. On any favourable night, a cursory inspection of it shows that through one-third of its course, it divides into two branches; which, after

flowing somewhat apart—leaving between them a comparatively dark space—reunite, and again form a single stream: so that a new hypothetical figure is needed to explain why, in looking towards the region where the stream is divided, the prospect terminates, not in *one* milky spot, but in *two*, separated by a considerable breadth of space, which has no greater number of stars, and not much more general illumination, than the *sides* of the cluster. To effect this, it is enough to suppose the cluster oblong as before, but divided or *split towards one of its extremities:* for it will readily be seen that if the Sun, *S*, were in a cluster similar in shape to the annexed figure, a spectator in it would necessarily discern one bright spot towards *B;* two equally bright ones at *A′* and *A″* in the opposite direction; and towards *C* and *D*, as before,



the background of the heavens would appear comparatively dark; while a third but limited dark space, of precisely the same character, towards the vacuity *A‴*, would separate the divergent branches.

Further, and very memorable elucidations of such views were soon yielded to Herschel by his great

telescopes: by whose aid he attempted not merely to gage or sound our starry sphere in every direction, but even to record and represent the minute irregularities of its form. The principle to which he trusted in these extraordinary investigations will easily be understood. Suppose one somewhere in a crowd—say in a large room, filled with people—would he not, on turning and looking around in different directions, *see a number of persons somehow proportionate to his distance from the extremities of the crowd, or the walls of the room?* If he saw a much greater number, for instance, when looking one way, than when looking another way, the inference would surely be natural that, in the former direction, the mass, or multitude of people, extended farther than in the latter; and it must be quite conceivable that an arithmetical rule might be found by which to *compute* the relative distances in the two cases, from the ends or limits of the assembly. The rule does exist, and is not complex: nevertheless, I am satisfied that its *possibility* be here recognised. Assume, now, a large telescope, capable of piercing deep into space; turn it in all different directions towards the heavens; count the stars in its field of view, in each position; calculate on this basis the distances from the extremities of our cluster: and the means are provided of charting —with an approach to accuracy—even the stupendous system amidst which we are. HERSCHEL was at once fired

by this idea; he termed the process a gaging the heavens—casting out lines, as we do at sea, to fathom and record its profundities. With his peculiar ardour and perseverance, he accumulated immense materials for the construction of such a sketch. Then, supposing *S* the position of the sun, and drawing in due directions, lines, corresponding in length, to depths indicated by the quantity of stars in each *gage;* the mere joining of the extremities of these lines gave the section required. Rude it assuredly was, and still ruder the

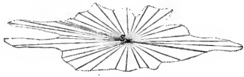


diagram now representing it; but a spot nearly of such a shape, must appear our entire System of Stars, from some distant region! Yes! if we could escape from terrene shores, and wing our way aloft through the gorgeous Milky Way, we should pass onwards for ages, speeding with the swiftness of light, ever in renewed amazement as we flew along, at the apparent exhaustlessness of its splendour. But lo! a barrier—a limit to stellar majesty, would in time be attained; a frontier with dark space before, and behind it, all that mag-

nificent scheme, we once spoke of as the UNIVERSE. Let us still sweep onwards, and look back again: there now it lies, dwindling in volume, and its radiance fading; until from some unmeasured depth, it assumes a form like that I have drawn—sending forth the faintest illumination, and no more than slightly interrupting the awful bleakness of space!

It is possible to suppose some inhabitant of the interior of an island amid the great Pacific so fixed to the neighbourhood of his home, that for him that speck of dry land had neither shores nor form, but appeared a sufficient and even ample universe. How astounding his first sight of the surrounding ocean—how small then, his former world; a point amid these everlasting waters! But tell him yet farther—of other isles in multitudes never reckoned, lying also on the breast of the same wondrous sea; some like his own in magnitude, others in groups; and again of mightier masses in the distance, forming majestic continents. Words are all inadequate to describe them; but precisely of the latter kind have been the more recent disclosures of the telescope. Confirming, by emphatic analogies, his conceptions of the character of our stellar system, HERSCHEL discerned that beyond it, among the spaces to which its own stars do not reach, other gorgeous clusters are resting; separated from each other and from ours, by gulfs, with which the

distances between the different suns around us, are no more comparable than our small units on earth are with them. One of these stupendous systems is feebly represented in Plate II., as it might appear to the most powerful of our instruments; even to a good telescope it is only like a speck; but what mind shall imagine the glories—the wondrous varieties of Being—that speck must contain! Such, our earliest glance of this new perspective: System on System, of majesty unspeakable floating through that fathomless ocean: Ours, with splendours that seemed illimitable—but an unit amid unnumbered throngs; we can think of it in comparison with Creation, only as we were wont to think of one of its own stars.

Since these memorable views were propounded by Herschel, the structure of our galaxy has been the object of much elaborate investigation; and in the main, the speculations of our great observer are confirmed. In attempting to unfold the existing condition of the inquiry, I shall be guided by that chart of M. Struve's, in which, with signal ingenuity and success, he has summed up the researches of Piazzi, Bessel, and Argelander.

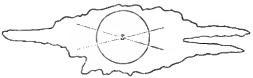
The aim of the Poulkova astronomer was the following:—Suppose a thin slice or disc, having the great circle of the Equator in its centre, to be cut out of our stellar sphere, he desired to lay down from observation, the numbers of the stars of the various magnitudes which would be found in it, and also the mode of their distribution. That his results might not be affected by uncertainties arising from our comparatively imperfect

EQUAT

XX XV

AL DISC

acquaintance with remote regions, Struve confined himself within the limit of stars of the NINTH MAGNITUDE: so that Plate III., for which I am indebted to him, does not pretend to pass to the extremity of our cluster in any direction, but only to show the structure of a part of it;—it is merely the representation of the contents of a thin circular disc, whose radius, probably, attains the term of existing perfectly accurate inquiry. In relation to Herschel's original section, it is, perhaps, not more comprehensive than the sphere within the circle in the subjoined diagram; but notwithstanding



the limited nature of its pretensions, we shall find it replete with interest and profoundly suggestive.

In constructing his chart, M. Struve proceeded in the simplest way. By aid of the best catalogues, he first collected and arranged, according to their magnitudes and *direction*, all the stars whose existence and position have been recorded, up to the boundary assigned by himself; and by some curious and ingenious means, he felt

enabled to conclude how many in each case had probably escaped observation. The *numbers* of the various orders thus completed, and employed according to the principle already explained (page 8), yielded an approximation to their respective *distances*, which are indicated on the line at the bottom of the chart; and then the astronomer proceeded to shade the various regions according to their density or *richness* in stars. The latter element was obtained as follows:—Taking the entire number of stars belonging to any magnitude, he supposed them equally distributed over the space belonging to that order—which gave him its *mean* or *average* density; and a comparison of the actual number of the same magnitude in any *hour* of right ascension, with this average, established the comparative density of such stars in that *hour* or direction. For instance, there are 37,739 stars of the ninth magnitude, which divided by twenty-four, gives 1572 as the average or mean density of this order—the density that would characterize *each hour*, if the stars had been uniformly distributed. But in the first hour, there are only 1084 of such stars; while in the sixth, we have 3318. Compared with the *mean* then, the density of that first hour is represented by 0.689, or about $\frac{2}{3}$ the adopted average or unit; while in the sixth hour, it is 2.11. Shadings in their proper places on the chart, of brightness proportional to the two numbers $\frac{2}{3}$ and 2.11 will

thus exhibit the construction of these two regions of the sphere: and in all its regions, and with reference to every order, it may, by a similar method, be made to express graphically the actual plan of the heavens.

We shall now study this remarkable chart, in search of the grander truths it contains.

I. It will not escape observation, that while characterized by a general uniformity, or rather by a strongly-marked plan, certain minor irregularities, especially within the sphere of stars of the sixth magnitude, also distinctly appear. These irregularities do not partake of any *system* hitherto apprehended. Spots of light in one place, comparatively faint districts elsewhere—they indicate in the heavens a variety characteristic of all Nature; and, as we shall discern afterwards, this too—even amid forms so august—seems to originate in the processes of change which diversify, and stamp with the cheerfulness of life, every other explored portion of the Universal Order.

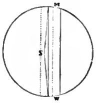
II. Overlooking partial irregularities, our attention is fixed on the main feature of our chart—viz., that grand irregularity, expressive of an extraordinary condensation of stars, along a *belt*, or *stripe*, crossing the whole disc, between the *sixth* and *eighteenth* hours of right ascension. Not only is that belt the densest

portion of the disc, but as we retire from it, stars of all orders become dimmer; for instance, the line or diameter from hour I. to hour XIII., or its neighbourhood, is, as a whole, the faintest in the sphere. Here, then, in so far as our equatorial disc is concerned, we have manifestly the leading district of our stellar system; —a stripe, or belt towards which stars of all magnitudes have, by some potent influence, been concentrated. And if M. Struve had, by similar methods, portrayed the aspects of the other discs above and below this equatorial one, as far as the poles of our system; his charts would have exhibited predominating belts running across them all,—so corresponding to the first and to each other in position, that they seem to *lie above each other*, forming as a whole one continuous solid slice, standing upon the equatorial disc, and rising upwards somewhat obliquely—penetrating all the sphere. It is not without considerable difficulty that minds not habituated to representations of solid figure, can comprehend the exact significance of a description like this; on which account, and because of the paramount importance of the point I would impress, I shall take aid from a homely illustration. Place before the eye an ordinary celestial or terrestrial globe; fancy that the wooden horizon passes entirely through the globe, and an idea will be had of the equatorial disc pictured by M. Struve. Again, let another section be imagined along

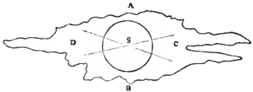
the direction of the brazen meridian, so that a thin slice be cut from that portion of the globe—*it* will nearly correspond with the massive region to which I am now referring—the region which, in our stellar system, includes the immense proportion of luminaries of every order; and which, if it be supposed accompanied by stars strewn comparatively sparsely through the spaces at its sides—will present the chief feature of the plan after which that system is arranged.

III. On turning again to the skies, in search of traces there, of the dense mass whose existence as a *rich vein* through our galaxy, careful observation has thus disclosed, we immediately light on the Milky Way. This zone is found to cross the equator precisely at those two points at which, in Struve's chart, we discern the belt of greatest lustre; so that the former phenomenon is merely the prolongation and external picture of the other. Concerning the Milky Way then, farther, and, in so far, very distinct statements may now be hazarded. If, from the sides of that superb girdle, planes be supposed stretched across the sky, they would enclose, as by gigantic walls, a space of shape like a common grindstone; and within this enclosure is the dense region of the starry heavens. The sun, it will be noticed by again referring to the chart of M. Struve, is not quite in the centre of the space between these

planes, but at a distance from it, ascertained to be nearly equal to that which separates stars of the second from those of the third magnitude; so that we look at it, not from *within*, as if it were the *dotted* zone below, but from a position slightly outside, as from S on the belt M W.—It will of course not be overlooked,

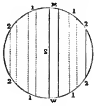


that we have yet penetrated only to the limit of stars of the ninth magnitude: so that the question remains, what is the nature and extent of the lateral spaces at A and B, continued from the fainter districts of STRUVE's sphere: and, how deeply—if that depth can



be measured—does the dense belt itself stretch before and after, at C and D, towards immensity? The first

inquiry can with some confidence be replied to,—M. STRUVE, as before, furnishing the means. On again examining Plate III., it will appear, even to the eye, that if zones, as in the diagram below, (1, 2, &c.) parallel to the belt of greatest density, be compared with each other, the more distant is always the fainter,



or the less rich in stars. Nay, this diminution is so certain and determinate, that the Russian astronomer has been able to ascertain its *law;* a law whose form, indeed, seems complex—that form, I mean, in which alone we can at present express it—but whose existence shows how emphatic is the fact, that, as we pass laterally away from the central stripe or disc of our cluster, the distances between the stars are found augmenting, *just as with the particles of our atmosphere among its higher regions.* In cases like the present, it is never safe to pass, on the strength of mere logic, beyond the sphere of positive observation; so that it were wrong to rely absolutely on the indications of any such law, as to the existence of a limit—that, too, not far off—

across which our system does not laterally extend; the dark ocean of space lying there fathomless, washing its shores: but I do not hesitate to record my belief, that the mysterious boundary has been visited, and these starry fields passed through, by telescopic energy. To clear all doubt away, to follow the irregular coasts of our cluster, in its shallowest regions; to survey its gulfs and headlands, and chart their forms,—these, with other grand achievements, await the application of the superb powers called recently into being by the genius of the Noble Observer at Parsonstown.

IV. The arduous question, however, yet remains—one whose solution will task the loftiest energies alike of mind and art. Through those untrodden paths of the Milky Way, can we pass with secure foot? Is the starry demesne endless there, or can the sounding-lines of human thought and vision cope with its profundities? I believe that in his earlier papers—having as yet no mistrust in the majestic instrument he had created—our immortal countryman spoke, with an excess of confidence, in his gaging powers; but that he duly appreciated the extension of the wonderful zone which, first of all men, he had dared to propose analyzing, appears elsewhere quite as clearly as in his remarks on the intractable depths of the spot in Perseus. The present

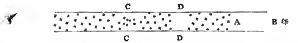
condition, of the inquiry will, I trust, be made plain by the following considerations:—

First. When an eye unaided, or with a telescope, is directed towards a prolonged bed of stars, there is no reason to fancy that it has reached the termination of that stratum, so long as behind the luminaries which are individually seen, there appears any milky or nebulous light—such light most probably always arising from the blended rays of remoter masses. But if, after struggling long with a nebulous ground, we obtain a telescope that gives us more stars, with a *perfectly black sky;* we then have every reason the circumstances can furnish, on behalf of the supposition that at length we have pierced through the stratum; a probability, indeed, which can be converted into certainty only in one way—viz., when by a still larger instrument no additional orbs are revealed. This latter test is *absolute;* it intimates a decisive exhaustion of the bed of stars: though it can be employed but rarely, in cases, demanding even for their imperfect investigation, the largest accessible telescopes. Asserted, however, by an observer of sound and reliable judgment, duly exercised in these most delicate inquiries—the entire dissipation of a nebulous background, seems virtually conclusive of such a point; for if it does not show the absolute and immediate termination of the stellar cluster at a certain special depth, it assuredly indicates

a diminution of its *density* so signal and rapid, that the proximity of a limit may safely be assumed. The phenomenon now referred to is far from strange; it cannot be unfamiliar to any one who, with extensive powers, has looked thoughtfully into the Milky Way; and Sir John Herschel, in his recent very interesting analysis of that zone, has adduced the occurrence of such perfectly *black grounds*, as bearing irresistibly on the point at issue —viz., our power to exhaust in certain places the riches of our stratum.

Secondly. At times, when this black ground has been reached, and also in other cases before it has been quite reached, another very remarkable phenomenon appears. In a field of view lit up with the splendours of the Milky Way, the eye sometimes discerns across these lights—deep apparently, in onward space—a cluster of stars, of trifling, superficial extent, but intense riches; and as there is no connexion, or at least no *continuity*, between the magnitudes of the orbs composing it and those in the stratum through which we are looking, we are constrained to infer that it is really *isolated;* that between the Milky Way and this cluster, there is a vast interval of untenanted space; and, therefore, that in this locality we have seen the termination of our Galaxy. The principle now employed is a very fertile one. Its authority is evidently co-extensive with

our fundamental proposition — *that the distances of the stars are indicated by their magnitudes;* and a slight reflection will show that it must reveal to careful inquiry not merely the termination of a prolonged stratum at *A*, beyond which an isolated cluster is found to lie; but also all irregularities within that stratum itself—a partial irregularity at *C;* or, at *D*, a break or vacuity. Dr. ROBINSON mentions two occasions on which clusters,



thus singularly associated, appeared to him, while using the great reflector at Parsonstown; and he speaks of them with especial interest, because of the light they cast on the structure of the Milky Way.—If, however, that vast instrument, with all the immensity of its range, can produce evidence nothing more than *probable* that it has sounded the Galaxy; through depths how inconceivable must our bed of stars stretch out, in those its more brilliant regions! And how overwhelming the thought, which first grew up in the mind of the veteran HERSCHEL; that, after all, this is no more than a speck—an islet on the breast of the great Sea!

It cannot, I think, be doubted, that by the truths now unfolded, the general views of the illustrious

founder of sidereal astronomy, as to the structure of our galaxy, are established. That the galaxy is a limited cluster, comparatively shallow in its lateral regions, while in the direction of the Milky Way it stretches indefinitely onwards, are propositions seemingly as nearly demonstrated as—in inquiries of this nature—it were reasonable to expect: but, farther than the broad statement, that we are in the midst of a stratum, which, viewed from above, might have something of the aspect of such masses as those in Plates V., VI., &c.—I presume that HERSCHEL himself, would not at present have been inclined to adventure. It is possible, however, to obtain a more accurate conception of the *internal* structure of this extraordinary stratum; with which aim, I shall request attention to certain additional remarks.

First. The illustration given above—which presents the Milky Way, within the region of stars of the ninth order, as a solid massive disc, rising obliquely from the Equatorial plane—requires considerable modification. We find, from our best catalogues, that the density of the stars does not augment with signal rapidity in the neighbourhood of the Milky Way, until we have gone outwards to the sphere of the *smaller magnitudes.* Nearer us than the sphere of orbs of the *sixth* order for instance, M. STRUVE's chart shows no *very remarkable* accumulation in the line of the *predominating belt,*—

there is enough, perhaps, to evince some aggregating influence, within the plane of that belt; but the central part of the disc is far from being a *regular continuation inwards*, of the masses in the Milky Way. It is after we pass the eleventh or twelfth order of *distances* only, that any extraordinary increase of relative density marks those regions; intimating, apparently, that then we are touching the interior surface of something like a *ring* or *annulus*, encircling the spaces containing our sun and the luminaries nearer him: nor, in so far as this is concerned, would we be greatly in error in suspecting that the Stellar scheme to which we belong, might partake of the singular form portrayed in Plate X., fig. 1, if the central regions of that figure were not quite so vacant of stars.

Secondly. But a narrower scrutiny of the structure of this apparent ring, prohibits the conception that our system is characterized by any approach to regularity. It is, indeed, only to the most careless glance, or when seen through an atmosphere of imperfect transparency, that the Milky Way has the appearance of a continuous zone. Let the naked eye rest thoughtfully on any part of it, and if the circumstances are at all favourable, it must seem rather an accumulation of patches and streams of light, of every conceivable variety of form and brightness; now side by side; now heaped on each other; again

spanning across dark places—intertwining and forming a most curious and complex network; and at other times darting off into the neighbouring skies in branches of capricious length and shape, which gradually thin away and disappear. Plate IV. is an imperfect representation of a portion of this extraordinary zone in the neighbourhood of Cygnus—rapidly sketched during a late favourable evening. An attentive examination of it, however, will avail more than description: and surely it is complicated enough to render the inquiry as to its significance next to hopeless. There is one very prevalent and not unnatural idea of which the student must dispossess his mind, as a first essential to any comprehension of these marvels. The masses he sees in the Milky Way are not, as *on the face of a picture*, necessarily either at the same distance from him, or connected with each other. He is looking, on the contrary, deep into space; and these luminous forms are the contents of space presented according to the laws of the only possible perspective. A dim streak, for instance, is probably not dim in itself, or less gorgeous than the brighter one it seems to cross; but only a branch of our most complex system, at some inconceivable remoteness, lying athwart the field of view—a portion of one of its far-off convolutions. That this is an accurate interpretation, is amply confirmed by any telescope which can resolve these various masses into discrete stars; for the magnitudes of the bodies compos-

Plate IV

E THE MILKY WAY

ing them are neither corresponding nor continuous—they belong to orders indicating very different profundities in space. The view we enjoy, in fact, is, in its chief characteristics, not unlike what would appear to a spectator near the centre of the superb spiral nebula in Plate XII., when looking towards its circumference: there, as to us, branches and masses, of all degrees of remoteness and comparative brightness, would be presented in one glance before the eye; reason alone could disentangle the complex appearances, and reveal their relations as to distance. Thus regarded, our surrounding zone assumes its true magnificence; and before such majesty we must indeed be mute. In that peculiar state of our atmosphere, in which the cumulus cloud predominates, ranges and banks are usually seen, rising above and behind each other in gorgeous perspective—building up a noble and endless landscape of such hues and forms as occupy one's dreams: such—even thus, would appear the Milky Way, if at a breath its surface should part, and through the opening, we saw its ascending cumuli of star clouds, stretching away in unrivalled glory—higher and higher, up to where man's eye will never reach them, or his most vaulting imagination break in on their repose.

Lastly. One other fact connected with our system remains to be noticed—one especially dwelt on by Sir

John Herschel, in that work on the Southern Skies, in which he has worthily closed the greatest, most complete, and most classical series of inquiries yet possessed by sidereal astronomy. On the background of the sky, in regions not *apparently* connected either with the Milky Way or any foreign cluster, the acute observer I have mentioned has been frequently called on to remark, instead of that perfect darkness usually characterizing recesses which no star illumines, 'an exceedingly delicate and uniform dotting, or *stippling* of the field of view, by points of light too small to admit of any one being steadily or fixedly viewed, and too numerous for counting, were it possible so to view them.' He has specified no fewer than thirty-seven places distinguished for this strange and evanescent presence—the shadow, as if of some far-away reality, of a light blushing through the darkness. The phenomenon, indeed, is so faint, that he says, 'the idea of illusion has continually arisen subsequently;' but as to its reality, it is enough to read from Sir John's Note-book, 'I feel satisfied the stippling is no illusion, as its dark mottling moves with the stars as I move the tube to and fro;' and more that is similar. What, then, are these intimations from beyond abysses so awful? On examining, by aid of a stellar chart, whether the patches of light could be grouped in any consistent or intelligible manner, the same Astronomer found that, with the exception of *three*, that seem out-

lying and disconnected, they form several distinct but continuous streams; and it appears, therefore, that as they must be held to be starry regions of great extent and excessive remoteness, we are constrained to consider them branches or arms of the system of our Milky Way, amid depths to which no adventurous conception ever penetrated before! It is far from the least singular of these recent revelations by Lord ROSSE, that, attached even to the simplest and most regular shapes of the external clusters, are stray filaments, dim and sparse, (Plates V., VII., &c.,) groping outwards, as it were, from the mass of the system into surrounding vacancy: are *these*, such arms attached laterally to the principal regions of our Galaxy, or are they portions of its general structure piercing into vacuities yet more wild and perilous, and carrying its relations onwards towards the sphere of other systems? Whatever their character or function, all hope of giving form or definite outline to the Milky Way now necessarily disappears: we are dealing with magnitudes so vast, so transcending measurement by any palpable unit, that they merge into what is formless.

The reach of the Modern Astronomy is now before us. It is concerned with the analysis of systems magnificent as our galaxy; it would sound their depth, determine their form, question the relations of their constituent orbs, and trace their distribution through space. Different, indeed, from that science of a recent day, limited to discussions concerning the locality of a few dependent bodies—the opake satellites of our sun—and which, when it had followed their course, deemed that its volume might be closed! There was true prophecy in the exclamation of La Place, who, although then knowing more of the celestial mechanism than any man, said earnestly on his death-bed —'That which we know is little; that which we know not is immense.' And the spirit was partaken of by Newton, in the very flush of his immortal discovery; when, with the modesty of all great minds, beside whose infinite aspirations the highest possible attainment is ever insignificant, he is recorded to have spoken thus:—'I am but as a child, standing on the shore of the vast and unexplored ocean, and playing with a little pebble which the waters have washed to my feet!'

But this she knows in joys & woes,
That saints will aid if men will call:
For the blue sky bends over all!

CHAPTER II.

THE EXTERNAL GALAXIES.—CLASSIFICATION ACCORDING TO THEIR FORMS.—THEIR DISTRIBUTION IN SPACE.

AMONG the regions where now we propose to adventure, Twilight reigns. They are the regions in which, faint as shadows, those vast galaxies are strewn of which our own glorious one is an illustration, and whose remoteness has dwarfed them into clouds of an hair's breadth. The watchword for the Wanderer here, is solicitude, as well as reverence.— Let us ascertain first, by what rights, and with what securities, we may feel ourselves environed amid abysses so dread?

I.

In researches thus evanescent and arduous, our reliance is, of course, wholly on the telescope: wherefore it behoves that, however briefly, we ascertain the source and measure of its power. Fortunately, the principle on which that power depends is most simple; nay, the

smallest and rudest instrument involves a full expression of it.—To produce the *sense of seeing*, it is necessary that a quantity of light enter the pupil of the eye. Now light itself—overlooking the consideration of its *intensity*—radiates from every luminous point throughout all space; so that if the simple reception of light were adequate to the production of vision, no material point from which rays stream, could, however small or remote, ever be invisible; but inasmuch as the rays from any object become thinner and fainter as we recede from it, a limit is soon reached, beyond which the *quantity* reaching the eye is insufficient to enable the object to be perceived. The quantity of light, however, which enters our visual organ, in any given case, depends on the size of the opening that receives the ray—viz., the *pupil;* so that if, by the processes and ingenuity of Art, we could *virtually* enlarge that pupil, our sense of sight might be rendered more penetrating precisely to that extent; and fortunately, one of the most widely recognised characteristics of light has enabled us in this way to overpass the boundaries of natural vision, and altogether change our relations with the scheme of external things. In the diagram below, the point *S* is represented sending

out luminous rays, as usual, in straight lines — rays which fill up, growing fainter as they recede — the triangular space $A\ S\ B$. Now if a transparent plate, termed a lens, were placed at $C\ D$, so that all the rays filling that space fell on it; they would—because of an operation of the plate depending on its *shape*—not pass through it in straight lines, but be made to *converge* behind it, and collected into one brilliant pencil, sufficiently small to enter the pupil of the eye. The eye, it is manifest, would then receive from the point S, not the small amount of light naturally capable of occupying its narrow pupil; but the whole mass passing through the large plate or lens $C\ D$: the star, no longer on the verge, perhaps, of invisibility, would shine with a splendour immensely increased; and one cannot name a remoteness so profound, through which our human sense might not, by an aid so simple and yet so memorable, be enabled to follow its radiance. The extent of this new and unexpected power is limited only by the size of the plate $C\ D$; for *that* is the measure of the quantity of light effectually condensed; and if one considers that the average breadth of our small pupil does not exceed one-fifth of an inch, the power gained, and the revelations effected, even by an inferior instrument, must cease to be matter of amazement. No wonder, indeed, that the rude tube of GALILEO sufficed to unveil the spots of the Sun;

changed the face of the Moon from a mottled, unintelligible disc, into a world, checquered by mountains, valleys, and extensive plains;—that to an instrument which one can carry in one's hand, that speck of brilliant light, the planet Jupiter, reveals himself as a majestic globe, the centre and ruler of a large scheme of dependent satellites; that Mars tells of his continents, and oceans, and polar snows; and the distant Saturn displays his gorgeous Ring; — less marvel still, that HERSCHEL, by gradually enlarging his metallic discs with the growth of his experience and mechanic skill, until he reached the perilous adventure of a FOUR-FEET mirror, passed by gigantic strides through regions of the Universe, to which imagination, in its wildest moods, had never essayed to penetrate before; or that now, after enjoying their peaceful triumph through the half of a century, even *his* discoveries must again, in some directions, undergo modification, because of the achievements of a tube whose vast eye is SIX FEET in diameter! This unparalleled enterprise, which it required the daring of highest genius to conceive, and skill the most consummate to accomplish, has reached a triumphant close; and although, from the nature of the objects to be examined, and the multiplex obstacles presented by the atmosphere and conditions of the earth, years must elapse ere its full survey be completed, we have already sure ground for asserting,

that it shall achieve in the work of observation an achievement as illustrious, as that which, through all time, must belong to the only enterprise with which Lord Rosse's can be associated—I mean the labours of Tycho, in his Castle of Uranibürg.

The labour and merit involved in the construction of a disc of metal so stupendous—one which must, on a general computation, augment that Universe distinctly visible to man, 125,000,000 times,—will not be ill appreciated by any instructed workman acquainted with the production of reflecting telescopes; but I would signalize it as the special deserving of Lord Rosse, that the process ultimately leading to success, grew under his hands through careful and deliberate efforts; he owed all to his mechanical skill and noble perseverance—nothing whatever, except the power to institute experiments, to any fortunate accident. But even when the metallic disc came perfect from the furnace, another task, hitherto unaccomplished, remained to be overcome. The size of the mirror is only the measure of its power to collect and compress feeble rays of light, incapable in themselves of producing the sensation of vision; but the telescope must achieve more—it must tell, not only of the *existence of light* we could not have perceived without it, but also the exact *shape and nature of the object* from which beams so rare proceed;—it must produce in

its focus, not that mere blazing illumination which one causes by the use of the roughest sun-glass, but a perfect image of the star or other luminary towards which for the time it is directed. Now, unless—by the processes of grinding and polishing—a certain *definite shape* has been impressed on the speculum with an almost *geometrical exactness*, that speculum, instead of an image of the object, will yield only a distortion; and when it is recollected that in examining the image produced, we desire to employ very large *magnifying powers*, it cannot seem remarkable that the slightest deviation must be fatal—being converted by these into an amount of distortion adequate to conceal utterly the inner structure, and even to disguise the leading features of the object we would explore. The ingenious Mr. BARTON—a mechanician who has conferred a very extraordinary perfection on the arts of turning and grooving—proposed at one time that we abandon the usual practice of *grinding* in this case; and endeavour to communicate both polish and figure to the metal, by turning it with a *diamond point*, whose motion should be determined by mechanism, even to a geometrical nicety; and which would leave on the surface, only grooves so fine that they would reflect light, as if the polish were perfect: but, considering that a deviation from truth, by the fraction of a hairbreadth, would vitiate the figure; and that accuracy so remarkable could not be secured in the working

of an instrument somewhat complex, whose parts are all subjected to change of temperature and other disturbing causes, we can scarce regret that Mr. BARTON'S conception has not been put in action on any extensive scale. The problem, in fact, is one which by its nature defies *direct* solution; nor do its most essential requirements admit of being implemented, unless by some process which can *correct its own defects*,—as, for instance, the well-known mode of producing a surface perfectly spherical, wherein two surfaces are rubbed on each other in all possible positions, until, by their mutual action, the figure demanded is necessarily impressed upon both. In obedience to the practical instincts distinguishing every great mechanician, Lord ROSSE, therefore, adopted from the beginning this idea, as the guide of his endeavours; and his success has been so great, that the production of a speculum of any size and of perfect figure, has ceased to be a question of chance. Through the use of his simple machine, these superb discs, that receive and compress all impulses reaching them from whatever depths of space, are made to represent, with an exactness hitherto unobtained for the microscope, the precise object from which the feeblest pencil arrives — they show its contour, its colours, and their evanescent shades, so that in very truth it has become our neighbour, in no way strange any more. There is a minute point near POLARIS—

so minute that it requires a good telescope at all to discern its being; I have seen it, as represented by a large mirror, blazing like a star of the first magnitude, and though examined by a potent microscope, clear and definite as the distinctest of these our nearest orbs, when beheld through an atmosphere not disturbed. Nay, through distances of an order I shall yet scarce name—distances so stupendous, that light in its rapid course would fail to traverse them in many thousands of years—I have seen a mass of orbs, compressed and brilliant, so that each touched on each other, like the separate grains of a handful of sand; and yet there seemed no melting or fusion of any one of the points into the surrounding mass; each sparkled *individually*, its light pure and apart, as that of any constituent of the cluster of the Pleiades! With acquisitions so grand then,—in possession of organs like these—shall Man hesitate or falter, or doubt that he has reached the beginning of a new and grand era? It would seem almost as if the telescope were discovered anew; or, at least, that an epoch like that of Herschel has come round again.

II.

The appearances of the objects which come within sight, when, with instruments thus gifted, we sweep these profound spaces, vary in many respects with the powers

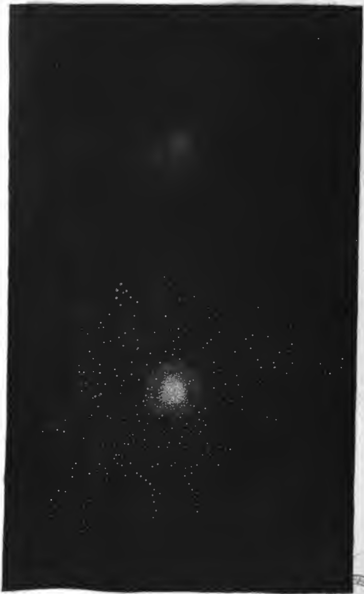
of the telescope, as well as with the nature of the objects themselves; and there are certain considerations connected with the former cause of variation, on which it is requisite to bestow a degree of notice, so that, as our inquiry proceeds into the actual structure of these clusters, no avoidable ambiguity may remain.

I. These gorgeous aggregations present — even to a telescope which, compared with any of HERSCHEL's, would be termed an inferior one—the same varieties in their *general* features which more perfect instruments descry. The larger and nearer masses are easily seen with sufficient distinctness to reveal the grand fact decisive of their character—viz., that they consist of multitudes of closely-related orbs forming an independent system. The superb object already referred to (page 23, and Plate II.) may be safely assumed as a type of this class of appearances; for although few are so extended and magnificent, or so remarkable for a certain systematic simplicity of shape, our *representation* of that cluster is not adequate to the splendours of the most ordinary among them. In other cases, we find the individual stars by no means so thoroughly defined. Through effect, in all probability, of distance, the intervals between them are greatly less, the shining points themselves also being fainter: while masses still farther off may best be likened to a handful of golden

sand, or, as it is aptly termed, *star-dust*, beyond which no stars or any vestige of them are seen, but only a patch or streak of milky light, similar to the unresolved portions of our own surrounding zone. These different appearances are shown with considerable exactness by various objects in the succeeding plates, especially Plates V., VI., VII., VIII., and IX.; but that many of the peculiarities they express are *apparent* only—not essential to the object or manifesting specialties in its constitution—is evident from the fact that they *change under the inspection of larger telescopes;* those whose stars were fainter becoming distinct and lustrous as the others of the first order; and the nebulous spots losing all trace of their previous inscrutableness. To every such instrument, indeed, even the most powerful hitherto created by art, numbers of these masses are revealed, of all degrees of distinctness; but this only because its immense sphere is far from exhausting the space through which the majestic stellar arrangements are diffused, and must therefore present objects in all different relations as to distance.

II. But while the appearances of the nebulæ, as to their *constitution*, are affected by the degree of telescopic power applied to them only in a manner so simple and so little puzzling as this, it is different as to their *shape*. Instruments of inferior energy, showing nothing of a cluster except its brighter parts, usually give us a picture

Plate V



NEBULAR CLUSTERS

SEEN BY [illegible]

of it, which resembles, in but few important features, the form unfolded by a power more adequate to explore it; and this so much the more, as in the greater number of instances the *faint* portions of these stellar arrangements, far surpass in extent, and frequently also in interest, the comparatively limited spots around which the stars happen to be concentrated. In the course of the succeeding remarks, illustrations of this fact, striking and numerous, will come so often under inspection, that it is not necessary at present to occupy ourselves with details; but the general inquiry is evidently a vital one—*How far can we rely on any revelation made by the telescope, as to the actual shapes of the nebulæ,*—to what extent and in what circumstances shall we be safe in inferring what is *real* in this respect, from what is *apparent?* Alas! even thus early, we are encompassed by doubts, and in contact with difficulties that are insuperable; but although the removal of the obstacle exceeds our power, careful inquiry may discriminate its nature and ascertain its amount. There are three points deserving notice in relation to this very important subject.

First. There is one case, and probably only one, in which we may conclude, that the telescopic picture of a nebula is the complete one—the case to which I have already referred as establishing our exhaustion of several branches of the Milky Way. If two telescopes, widely

differing in power, offer to the eye the same representation—the larger one adding nothing, either in stars or branches, to the previous appearance of the cluster, we shall be safe in always believing that it lies before the eye in its completed form: but, without waiting for an occurrence rarely accessible, the observer—also as with our surrounding zone — may conclude, without hazard of error, that he sees the entire phenomenon so soon as all mere *nebulous light* disappears from it, and it shines forth a system of pure stars. Even this achievement is arduous, but it has been accomplished. Before the completion of Lord ROSSE's three feet reflector, the cluster in Hercules, though as distinct as it is gorgeous, never appeared devoid of unresolved light about its central regions; but on the application of that mirror, every diffusion arising from the blending of separate stars disappeared, and the galaxy was wholly unveiled. In this, and all similar instances, the telescope must have pierced *through the cluster*, so that no farther light could be thrown on it by any conceivable augmentation of power.

Secondly. Cases like the foregoing are alike rare and fortunate. Generally speaking, every increase of the instrument with which a nebula is being explored, modifies its shape, by revealing attached branches unseen before. Now, where shall this stop; and if stop it does not, what security have we while speculating on merely

half-seen shapes? There are but two rules for the judgment in the difficult circumstance. First, we must rest no speculation on the ground that the figure—as we see it—is *complete;* far less that any actual nebula partakes of a perfectly simple or geometrical form. We might speculate, for instance, on the idea that a nebula is an uniform sphere like the form of Fig. 2, Plate IX.; and lo! with another instrument it reveals itself as the extraordinary shape of Fig. 2, Plate X.! *Again:* If we speculate at all, or venture general conclusions regarding objects so obscure, it must be on the basis of *positive* revelations,—discoveries that will remain untouched, whatever else may be *added* subsequently by advancing knowledge. No one, for example, would be at fault in attributing the absence of accumulated light near the centre of the small disc now spoken of to the *hollowness* of the actual figure: nor can the uncertainties which still envelop the structure of the great spiral of Plate XII. impair the certainty of the remarkable fact, that its immense rings, which formerly seemed perfectly uniform, are really composed of discrete masses. Hints such as these I do not offer as critical canons; but only to satisfy my reader that even amid this obscure, there is light enough to guide—onward in so far—the scrupulous and resolved inquirer.

Lastly. The greatest difficulty remains to be men-

tioned. It must never be forgotten that the figure revealed by the telescope, even when complete, is only *one section* of a solid mass. Now the aspect of a body of *three* dimensions, seen in circumstances which have no laws of perspective, can never enable us to conclude what the actual figure may be, which presents us that face. Who dare pronounce, for instance, on first looking at the Milky Way, respecting the intervals which would be formed to separate its various cumuli and branches, if we could follow them deep into space? Or immeasurably farther,—who shall declare the significance of these diffused arms of Orion, in Plate XVII., or how far its fainter regions lie behind those brighter spots which we may fancy to be the nearest? Unless in the rarest of cases, we have, indeed, no positive reason to infer the actual form of any nebula; how, then, speculate on that form, or concerning the forces that sustain it? Here, again, we are amid darkness, perilous almost as night. But we forget not that over this great universe law stretches its sure dominion, and that the reason of man is framed to discern it,—aid, accordingly, and hopefulness speedily reach us. Among objects countless as those environing galaxies, there must, in virtue of the action of law, be *multitudes partaking of similar forms;* and the probability is, that several of them will be found with the same *side*, or section, fronting our world; thereby showing corresponding shapes, and pointing out one

special arrangement as part of the established order. Further, it is equally likely that individuals of the same class will present toward us, also the *opposite face;* and if we can thus become acquainted with the *two chief sections* or aspects of the mass, we may conjecture securely, as to its true or solid form. Uncleared, indeed, and rugged, but still there is a path even in this unpromising land; and already men have clomb so far, and descried the height towards which to strain.

III. I have spoken of the nebulæ as separate and independent clusters, each occupying its peculiar position in space:—now, it may be well that, in this place, we look to the grounds of this assertion. Every nebula is, of course, seen *through* a portion of the cluster amid which we are; on which account multitudes of stars not belonging to it are necessarily always in the same field of view. But between these stars, and the luminaries into which the external spot is resolved, there is no gradation whatever, even of an irregular or interrupted kind. The absence of *continuity*, indeed, is in every case unquestionable; and if we were justified in our previous speculations, in concluding the existence of breaks or irregularities in our own stratum, from partial interruptions of continuity in the order of its stars, no doubt can exist as to entire isolation here, or that these majestic clusters rest apart—with their peculiar destinies and relations—

amid the solitudes of space. It may be asked, *Is the separation absolute?* Amid the intervals which divide them are there no solitary stars, unassociated and without brotherhood, scattered through those dread gulfs? A question of *fact*, to be decided by the telescope alone: but, in the meantime, the existence of orbs thus solitary, appears at variance with the general truth, that AGGREGATION or ASSOCIATION, seems the law or co-ordinating principle of the Stellar Universe.

Such the sphere we are about to traverse,—such the powers with which we undertake the journey, and so grave its difficulties! With the latter ever in remembrance, I proceed to narrate what has been ascertained concerning the separate nebulæ.

So far as our knowledge extends at the present epoch, the separate nebulæ may be divided into three principal classes; not alone on the ground of resemblance of form, but because their different forms appear to shadow forth various phases of the intermingling of great Laws.

I.

I. Among nebulæ or clusters of the first class, I again refer to the cluster in Hercules (Plate II.) as their most gorgeous type. In apparent form, that cluster is approximately *spherical;* and although *sphericity* is not an essential characteristic of the class, it will be seen in other Plates (V., VI., &c) that the form is not an unusual one. Now, the *apparent* form,

in this and corresponding cases, may with all safety be taken as nearly the *real* form; for if such clusters are not spheres, they must be cylinders or cones, or some other shape having *a circular base or section;* and the probability is very small, that in so many instances irregular masses would present to us their only regular outline. This argument, in itself of no slight weight, is rendered almost conclusive by the fact, that the gradation of light or of the apparent density of the stars, has the central point of the figure *as its centre*,—a feature whose significance cannot be mistaken, for it is in no wise consistent with the hypothesis that we are inspecting an irregular aggregation. Grand globular masses, then, are in all such instances before the eye; not, indeed, spherical in the strict or geometrical meaning of the term, for when seen thoroughly, they have all irregular arms—as if *filaments*—attached to their circumference; but in this, they only correspond the more with the general order of nature, which is, never to attain, but to approximate merely to the rigorous and ultimate simplicities of science. — On a cluster such as that in Hercules, let the imagination for a moment pause—realizing, if possible, the vista from its interior. No bewildering zones, or mysterious patches, like our Milky Way, to a spectator from one of its central suns: but skies blazing with grand orbs scattered regularly around, and with a profusion to which our darker

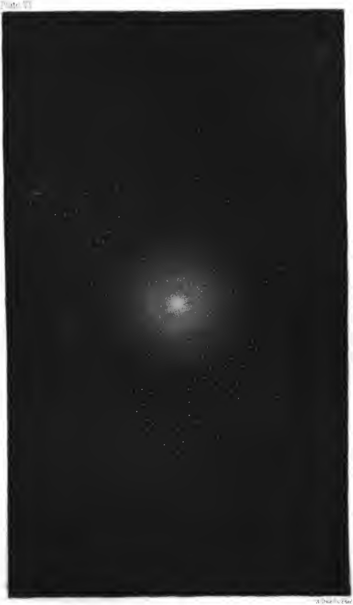
heavens are strangers! There, too, magnitude would lie behind magnitude, distinguished from what is around our world, by the entire uniformity of their distribution: nor, without the aid of some mighty tube, penetrating to these outer filaments, could a suspicion dawn on the mind of the hardiest speculator there, that his firmament is the speck we see it, instead of a single and only unfolding of the marvels and magnificence of the stellar creation!

II. But neither the spherical figure nor the simple gradation of light towards the centre, is the remarkable phenomenon connected with these masses: we are very early struck by the *mode* in which the light augments as we pass towards the interior region of such nebulæ. In certain instances, the appearance in question might seem explicable on the supposition that we are looking into a globular mass of uniform interior constitution; the central parts being the brightest, solely because we have before us there, the entire diameter, or greatest depth of the sphere, as in the subjoined woodcut,—

But an augmentation of splendour, owing to this cause, would be *regular* in its gradation, as we pass from the circumference towards the central point: and the facts observed, are not reconcileable with this hypothesis. The light, on the contrary, increases—perhaps with rare exceptions—at a rate *greatly more rapid* than the foregoing view can account for; intimating, without doubt, an increase in the *density of the stars* in the central districts of these clusters. The condensation or concentration, too, varies greatly in intensity: sometimes being far from remarkable; while in other instances it indicates a compression of orbs of a degree so extreme, that no mind can imagine the glory of skies they constitute. Often, also—as Sir JOHN HERSCHEL has remarked of the beautiful cluster which I have ventured to copy in Plate VI., from his memorable work on the Southern Heavens—this concentration proceeds, not regularly, from circumference to centre, but as if *by starts*, constituting well-marked stages of light; just as, on ascending a mountain, we traverse, at various altitudes, level districts or plateaux, before reaching the final cone. The reader must not,

however, be misled by my illustration, or attribute to these clusters any specialty of *contour* corresponding with their

Plate VI



CLUSTER WITH CENTRAL CONCENTRATION

gradations of brightness: although, in certain cases, the eye itself might be deceived into such an idea,—the central part of the nebula of ANDROMEDA, for instance, (Plate XIV.,) when seen by an ordinary telescope, forcibly impressing one with the feeling of an actual elevation there—a positive cone of light. The phenomenon is simply as I have termed it, a concentration or condensation of stars, proceeding—in cases like the foregoing—by strange gradations, as of steps or stages: and in another class of appearances, the absence or interruption of easy unbroken transition, seems more remarkable still. I refer now to the NEBULOUS STARS—objects of which Fig. 2, Plate IX., was, until lately, our best representation—each appearing as a single and perfect fixed star environed by a halo. These curious objects, which, as we shall see hereafter, have played a noticeable part in recent scientific history, are at length freed from all mystery: they are small clusters whose compression is *intense*, environed by a coarser spherical mass. Fain would I linger and revel again among the outward signs and wonders of these great firmaments; but a new order of meditations speedily occupies all the mind. This prevalence of the spherical shape—this growth of light towards central districts — this varying intensity of central compression — are not these things pregnant with the instruction contained in the rain-drop? Why is our small earth a *sphere*, unless because the matter

composing it is instinct with the energy we have named *attraction*—the tendency of particle and particle to become an aggregate—all being disposed thereby, to arrange themselves into that most compact form? I will not, indeed, venture to transfer to these august starry Universes the formal expressions of any terrestrial scholastic science; but—shaking from my mind them all—surely, even amid those depths, and the majestic creations filling them with vitality, I behold also tendency immanent, Power ever unfolding—ay, and Progression, uniform, ceaseless, harmonious, instead of dead unchanging charts of things!

III. The conception which I have felt authorized to utter thus reverentially, enables us to give considerable extension to the class of nebulæ we are exploring. I would term it, *the class whose form and general phenomena emphatically indicate the presence and preponderating action of a clustering or concentrating energy.* Now, as can easily be imagined, this special characteristic may occur although the masses are not spherical—nay, even in cases of apparent deviation from all regularity of shape. For instance, notwithstanding recent analyses by Lord Rosse, it appears not improbable that *elliptic* or *oval* nebulæ exist, and are even not rare, in which gradual accumulations of light about the central region—that region being frequently not a

point, but an *oval disc*—seem to indicate that the object is really a disc or spherical slice, seen sideways; and that its stars are compressed in the interior: but so many singular and unexpected facts have been revealed concerning such masses by the Parsonstown telescopes, that confessedly, speculators in this field can scarcely use an excess of caution. Further on, however, among forms much more capricious in appearance, our steps become more secure. The strange form in Plate VII. represents, as seen by Lord Rosse's three-feet mirror, the object which Sir John Herschel, in his Review of the Northern Nebulæ, figured as a small and dull ellipse; and—amid the irregularities now disclosed—that ellipse is still easily recognised; viz., the massive central portion of the cluster. Now, this principal region, is quite reconcileable in shape, with forms which a quantity of material particles—whether atoms or stars—would assume under the influence of attraction; and its internal structure corresponds also with the idea of the equilibrium of a system governed by such a law. Strip it, indeed, of its singular filaments, and this nebula might be quoted as an emphatic illustration of the agency of a clustering power. Still more with the form in Plate VIII. This is the celebrated 'Dumb Bell' nebula of Sir John Herschel, also as seen by the three-feet reflector. It could not, indeed, have resulted from the action of a clustering or attractive energy around *one*

centre; but we are not constrained to regard these strange objects in their present condition as compact and completed *unities.* In this instance there are *two districts* around which the orbs appear aggregating; and if we carry our thoughts on through duration, there is nothing about that singular object to hinder the supposition, that it may yet break up into two distinct and independent masses, each perhaps environed for a time, by a portion of the obscure branches which now fill up the lateral faint hollows. I know that in adventuring on such conjectures, and connecting the idea of *change*, with masses, whose days must be equivalent to man's eternities, I am chargeable with much of the rashness I have deprecated; but sustained by the conviction, that one grand inherent tendency, has left its footprints over all these skies, I ask again, whether, even in the Spiral of Plate XII., we may not discern that energy in the discrete structure of its rings, which are only continuous streams of minor but independent clusters? The elevation to which we are led by ideas like these, is indeed, a dizzy one, aloft from the usual haunts of Thought; but we are speaking of the higher ordinances of a Being, beneath whose awful unchangeableness, even processes so solemn and far-reaching, are, as before human vision, the opening of a leaf of the evanescent flower.

IV. Should it be recognised, then, that the aggregat-

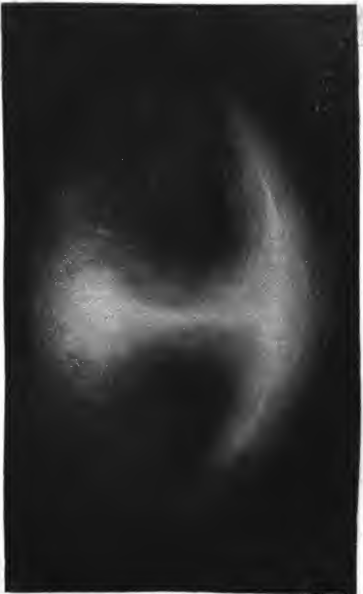


Plate VIII

ing energy I have described, carries its sway farther than the regular masses whose structure first suggested its presence—that its energy may be traced among the larger phenomena of the heavens, unfaltering and universal, as on earth—the inquiry becomes unavoidable, whence those deviations, those capricious features in so many of its spheres of action, marring its influence, or at least disguising its effects? I have said that not one of the nebulæ we term spherical, strictly deserves the appellation. How perfect soever their form may appear to a moderate telescope, like the object of Fig. 1, Plate V.; apply a more discriminating power, and the circular mass changes, as in this instance, into the figure below it on the same plate,—one of no uniformity of outline, and merely approximating to a sphere. So also, it will be recollected, with the Crab nebula of Plate VII.; and in like manner with all. Whence, then, these external filaments? It is not thus with the rain-drop, nor, speaking generally, with the shape of any planet; neither can any modification of an attractive power throw light on a phenomenon which yet appears so predominant. Are these filaments mere irregularities, *caprices*, or *anomalies?* Such terms are significant in relation to man's apprehension merely; they have no representatives in Nature. That waving wreath of smoke —less consistent than the transparent air—follows, through its disturbed ascent, a path fixed as the course

of the mighty sun; nor is it otherwise with the rugged outlines of the astral clusters. The groups and ranges of mountains which slightly corrugate the surface of our world were once deemed excrescences only, and the application of the word, appeared to explain them: but, interpreted by a better philosophy, they are seen as the results of a grand law unknown before, whose manifold and stupendous workings are the theme of a science scarcely less attractive than astronomy itself. Perhaps, in like manner, there is some influence we have not hitherto descried among the celestial spaces, in conflict with the attractive energy—a power not destroying it, but intermingling with it, and modifying its action? Further raising the dark veil, let us attempt to discover this energy even as we found its companion.

II.

I. As we start on this novel research, a class of bodies comes under review, whose history, as well as their phenomena, is alike singular and instructive. The objects referred to, appeared, during the early years of our acquaintance with them, essentially anomalous. In form they seemed *circular*, quite as much so as the most perfect globular cluster, but *they gave not the remotest indication of a gradation of light towards their centres;* on the contrary, their surfaces shone with a dim,

Plate IX.

3  4

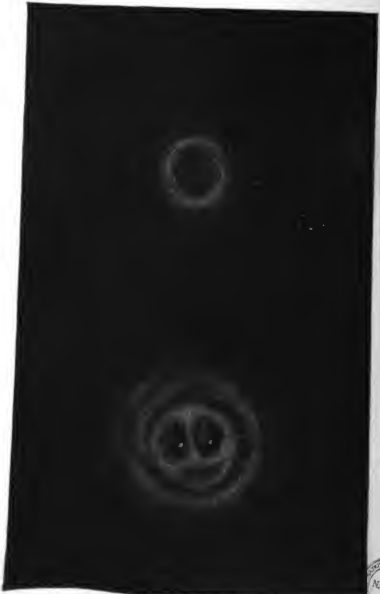
NEBULÆ.

SEEN IN 18 INCH REF...

equable brightness, not unlike the disc of a planet—whence their usual appellation of PLANETARY NEBULÆ. In Plate IX., Fig. 2, I have given a representation of perhaps the most striking instance of the class—the one near β, *Ursæ Minoris*—as we imagined it to be, previous to its inspection by Lord ROSSE: and it will not be difficult to judge, from the picture, why these nebulæ were deemed most puzzling. Notwithstanding the intimation apparently conveyed by the *circular* form of the object, the absence of all gradation of light from the circumference, inward, quite negatived the idea of its being a *spherical* cluster; for, as shown in the diagram of page 61, no such cluster could manifest an uniformly-illuminated surface. Is it, then, a cylindric mass of stars, with the round end toward us? Or, as an extreme case of the same hypothesis, may we not fancy it *a thin disc*, with its flat side in the direction of the earth? No such form, indeed, would consort with the assumed sovereignty of an universal attractive energy: but — whatever the laws predominant among these spaces—it is absolutely fatal to hypotheses of the description of the foregoing, that, while the bodies in question might lie indifferently in all varieties of position, we are required to believe that—without either known cause or imaginable purpose—many of them have been placed in *one particular relation* to the line of our vision. Systems of orbs shaped as circular discs might,

indeed, exist amid immensity, and be sustained by influences yet unrecognised by man; but that numbers of them should be suspended with the precision requisite to reveal to our terrestrial star-gazers only their circular faces, would involve something so incredible, that explanations resting on it, never were proposed save in jest—to be speedily rejected again: and accordingly, the favourite solution of the difficulty seems to have been modifications of an idea first expounded by M. ARAGO. Abandoning, as apparently hopeless, the notion that these objects are clusters of stars, or partake anywise of a stellar constitution, this eminent inquirer imagines them hollow spherical envelopes, in substance, if I rightly understand him, like a cloudy and opaque, or—at best—a semi-transparent atmosphere; that within this spherical film there is a brilliant central body, akin to a sun, whose rays illumine it; and that we see the film in virtue of light *coming through it* and scattered around it amid space, by reflection from its atoms or molecules! It assuredly will not be gainsayed, that something of a dim and uniform light, issuing apparently from a circular surface, might be provided by the ground glass shade of a lamp, or—the ingenious machinery of M. ARAGO!

II. The true explanation of the mystery has reached us at length—stranger, indeed, than the strangest fiction!



NEBULÆ WITH HOLLOW CENTRES

The reflectors of Parsonstown have shown that former telescopes *did not see these difficult objects aright*, which have no title to be designated PLANETARY NEBULÆ. Between the two stars β and γ *Lyræ*, lies a form not second in interest to any in the heavens. As drawn by Sir JOHN HERSCHEL, it is the large ring of Fig. 1, Plate IX.; and Lord ROSSE'S three-foot mirror analysed it farther, showing it as Fig. 1, Plate X.:—it is distinctly resolved, and therefore a grand ANNULAR CLUSTER of stars. Now, if this singular ring had been examined only by instruments far inferior to HERSCHEL'S, we might have altogether missed its central vacuity; for that region—being the *narrowest*—must come the *last* into sight. By small telescopes, indeed, the nebula may be detected in clear evenings, but, as to be expected, without the vacuity; and it then appears a *vague circular disc*, similar to a remote planet, or a comet wanting a nucleus. An incident highly illustrative of what we are considering is recorded in Sir JOHN HERSCHEL'S paper of 1833, regarding the ring represented beside that of Lyra, in Plate IX. This object is extremely faint,—'a mere ghost' are the words of the eminent observer; and on first seeing it—of course under inferior circumstances—he named it a '*Planetary Nebula!*' I must be permitted, indeed, to consider it remarkable—especially with facts like the foregoing, before me—that the absence of a gradation of light towards the central regions of this class of objects

remained enigmatical so long; and that no previous conjecture, approached the now positive discovery of Lord Rosse—*that in every instance examined, save one, the planetary nebulæ are nebulæ with hollow centres.* Before this simple proposition, all that was puzzling before, and the ground of so many hypotheses, at once disappears; but the reader must not conclude that the masses in question have either necessarily or uniformly *annular* interiors. It suffices for the *theory*, that this interior be in some manner void enough, to deprive the cluster of all approach to a solid spherical mass; an effect which may result from great varieties and specialties of arrangement. I rejoice that I can here present in illustration, one of the last and most signal achievements of the six-feet mirror. Look again at Plate IX., where Fig. 2 is the object I gave, as a large and perfect planetary nebula. Turn now to Fig. 2, Plate X.—that is the true form of the mass! Is there aught in Nature apparently more fantastic? And what shall we think of it, on recollecting the fact, that the incomprehensible vision before us is a dazzling galaxy of stars!

III. There are minor features characterising these hollow nebulæ, I would fain have had leisure to notice here. For instance—their interior regions are never wholly devoid of luminaries, as is intimated by the light more or less gauzy, which with greater or less regularity

Plate XI

[illegible] NEBULA
[illegible]

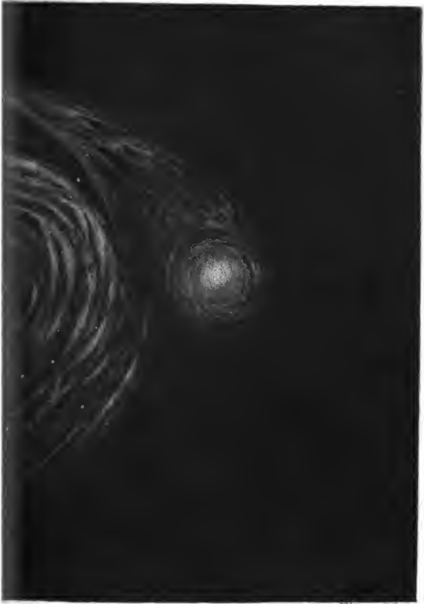
always pervades them. Again—their rings or denser portions are nowhere unaccompanied by *filaments*, like those attached to the globular clusters. Also—since these nebulæ must lie towards us in all varieties of *position*, they will not, when seen imperfectly, always appear as planetary discs: a ring, for example, placed obliquely, like the object in Plate XI., would personate an elliptic streak, with puzzling modifications of interior light: and in similar ways, enigmatic forms very various in character, must be evolved—mottled most strangely and apparently reconcileable with no law.—But we hasten from the sphere of details, to one profoundly remote—lying under all phenomena. These unconcentrated, or rather DE-CENTRALIZED masses of stars, bearing wide sway amid the celestial spaces,—behold *there* a novel FACT in Nature; not some incident attached externally to one of her manifestations, but an essential characteristic of her organism—the expression broad and clear, of one of the primal tendencies, which through time and space unfold her multitudinous forms! Vain the attempt to bring those enigmatic shapes into subservience to energies of the *attractive* order; their stability has no relation to the harmonies which sustain the Arch. Aloft, as before, from the preconceptions of our abstract mechanic science—observe the planet rolling for ever through its re-entering course, notwithstanding its tendency towards the sun. Whence

the stability of that exquisite motion? What signify the FACTS there, unless that—as in the special instance of the magnet—Nature is the unfolding of great POLAR forces, one which centralizes, and another opposite and conflicting—manifesting itself in diffusive or dispersing influences? One conclusion at least is irresistible: the extraordinary shapes we have just investigated are the indication of some *second energy*, whose peculiar character we may discern more clearly as we penetrate still farther among the dark regions of space.

III.

The truths which have already dawned on us, will, I am hopeful, enable us to contemplate with diminished bewilderment those yet more extraordinary arrangements whose structure I am now to examine.

I. When the careful and sagacious eye of Sir JOHN HERSCHEL re-surveyed our Northern heavens, an object was brought under notice, showing no trace of resolution or even of resolvability, but possessing on other accounts a very peculiar interest. In the telescope of this observer it appeared as in Fig. 5, Plate IX., a central spherical mass, environed by a ray—split into two branches through part of its course. Recollecting the chief feature of the cluster to which our sun belongs—viz. an engirdling



AL NEBULA

Milky Way, also divided along nearly one-third of its circumference—no marvel though sanguine minds hastened to recognise in the novel form, a corresponding or *twin*-galaxy, hung up at some enormous distance in space! Since that period, indeed, we have abandoned many previous notions regarding the simplicity of our surrounding zone; but *this* would by no means have marred its likeness to that nebula, inasmuch as from it too every vestige of simplicity has disappeared. The definition and resolution of this object seem to have been among the earliest successes of Lord Rosse; for in 1845 he gave as its representation the great spiral of Plate XII. If that and equivalent shapes have now grown almost familiar, thanks to his Lordship's continued inquiries; but, if it be regarded thoughtfully, never can a form so unexpected become divested of power to excite astonishment. Strange, indeed, and most complex! Judging it as we see it now, there is nothing to which to liken it, save a scroll gradually unwinding, or the convolutions of a shell: but we have neither explored its interior nor penetrated to its boundaries: the great mirror itself continues baffled and hopeless, in presence of those unfathomed nebulosities, which doubtless also are streams and masses of correlated stars!

II. Modern astronomical inquiry has perhaps unfolded no more extraordinary truth than the one now to engage

us. Improbable as it must have seemed, previous to discovery by unimpeachable observation, *the Spiral Figure*, as manifested in the foregoing nebula, *is characteristic of an extensive class of galaxies!* Majestic associations of orbs, arranged in this winding form—branches as above, issuing like a divergent geometric curve from a globular cluster; these rise up on all sides as the telescope journeys onward, supplanting shapes which we formerly imagined most simple—misled by their obscurity. It is assuredly singular that the objects in question, lie all at the greatest distances; which I presume is the signification of the fact that they are descried only by the most powerful instruments;—the existence, nevertheless, of a large number of them is satisfactorily established. Because of their remarkable frequency, it is natural to expect these nebulæ to be presented towards us in all varieties of position;—a circumstance never to be overlooked by the observer, because any amount of *inclination* must in so far alter and even mar the apparent characteristic regularity of their form. Another sketch, for which I am also indebted to Lord Rosse, forcibly illustrates the effect of such obliquity of position:—if the object had been turned only a little farther *edgeways*, we might have missed all recognition of its true shape. I refer to the fine nebula in Plate XIII. Previously this appeared only a dim, much elongated ray, with indications of clustering at its centre; but—

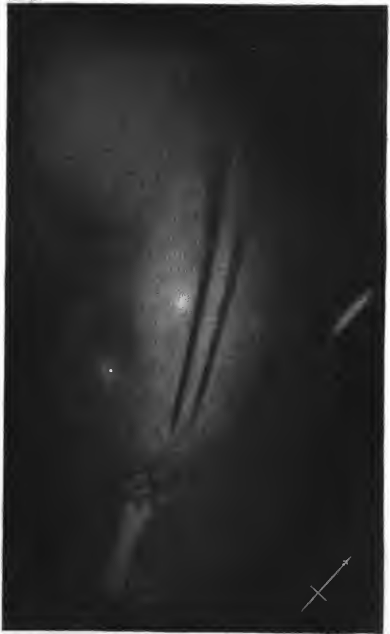
Plate XIII.

on the supposition that it is seen *foreshortened both ways*—the cause of its apparent peculiarities will now be understood if one looks obliquely at the figure of Plate XII., turning it so, that the central cluster seem thrown towards one of the corners.

III. A question of great moment can scarce fail to be suggested here. If spiral nebulæ are thus abundant, and accordingly lying in all different positions, must not some of them present towards us their *other principal section?* That is, must we not see them, in some cases, as if we looked at the spiral of Plate XII., from the top or bottom of the Plate? As I explained in an earlier part of this chapter, the probability of the fact referred to, and of our discovering it, is the measure of our hope of ever knowing accurately the *solid* or *real* shapes of these masses; but while the fact itself can scarce admit of being doubted, faint is the chance of our discovering it! We can unfortunately form no *previous* guess or approximate conception, of the shapes of spiral nebulæ when seen from the point I speak of: they may differ as widely from the other sections of the same bodies as the bottom of a pyramid differs from its sides; so that a prime difficulty lies at the threshold—how, viz., to assure ourselves that any form under inspection is another view of such a nebula? The thing must not be *seen* merely, but ascertained by some criterion to be

the *thing it is*, ere, for a purpose like the present, it can anywise avail; nor, perhaps, can a positive applicable criterion—supposing it to exist—become known to us, unless through the study of spirals very much inclined, and therefore turned *nearly* edgewise. In this utter absence of reliable information, will my reader excuse an agreeable fancy? One of the most superb nebulæ in the heavens is the famous one in ANDROMEDA. It is visible to the naked eye, being often mistaken for a coming comet; a good telescope discerns it as an elongated ellipse, with a region of bright light about the centre; no instrument yet known has proved capable of detecting its stars; but in apparent extent and form it has been greatly changed—witness its representation in Plate XIV., which is from the careful drawing executed at the Observatory at HARVARD. There is little that is intelligible about the form of that vast and obscure object. The amassing of light at its interior, indicates indeed, concentration of some sort, and it may be a manifestation of the clustering energy; but the feature which strikes us most is certainly no characteristic or effect of forces of that description. For the first time, I believe, —first, at least, in so marked a manner—the existence of *dark lines* WITHIN nebulæ, or as part of their structure, was noticed by Mr. BOND. And, indeed, a thing so extraordinary as these two black furrows running parallel to the chief axis of the nebula, could strike no

Plate XIV



GREAT NEBULA IN ANDROMEDA
(Harvard Refractor.)

one's eye without arresting it. Mr. Bond assures us that his drawing by no means exaggerates the distinctness of these remarkable openings, nor the suddenness with which they interrupt the light of the nebula: their edge is sharp, as if one had come unexpectedly on some abrupt cliff. In the very valuable paper recently addressed to the British Association, Lord Rosse alludes to these lines, speaking also of other instances: he seems disposed to regard them as important indications of *structure*, and refers to the vacancy apparent in his own oblique annulus (Plate XI.) as a striking example. Under such lights, what seem these dark lines in Andromeda? Again, observe attentively their characteristics: their direction is coincident with the greatest extension of the nebula; they are parallel to each other, or very nearly so; the interior one is the longer, and connected with the general mass only at its under extremity. Fancy, now, branches of a spiral nebula, not confined to *the same plane;* suppose that, as they wind around the central mass, they also move *outwards*—not like an *ammonite*, but a *helix*, or *turritella:* then might such intervals be intelligible — intervals between *successive whirls* of the starry stream! Alas! that the demesne of knowledge is so uncleared, that room may yet be sought on it, even for a vague speculation: but adequate instruments are now attainable; workmen hasten to its culture; a greater epoch has begun!

IV. A SPIRAL ORDER OF GALAXIES! Is Reason as unable to apprehend the forces which have evolved and sustained these as Imagination to realize their purposes, their magnitudes or the splendour of their interior? Mystery indeed—heavy, almost oppressive—hangs over all the perspective; but the shapes strewn through that bewildering territory have nothing in common with the fantastic creations of a dream. It is the essence of these nebulæ that they are not formless, but, on the contrary, impressed indelibly by SYSTEM, on the grandest scale: clearly as a leaf, they have an organism; something has seized on their enormous volumes, and moulded them into a wonderful order. But how shall we unveil this organism? where look for its origin and laws? Shall we endeavour to build up such forms, by combining star with star; by speculating on the relations of the several orbs or *atoms* which compose them, and of whose harmonies they are doubtless the sum or expression? As wisely, in the meantime, add fibre to fibre, in expectation to fashion the leaf; or refuse to examine the crystal, unless by means of hypotheses concerning the tendencies of its separate molecules!

If we would pursue this inquiry, we must at once forget the magnitudes of these masses, or that they consist of stars; they must be apprehended for the moment simply

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as streams of matter internally mobile, winding around central masses, and away from all external influences, rests freely amid space. Now, is it possible to inspect any one of these branches, without discerning the struggle there of the *two* great Forces whose existence we have discerned? It is, in fact, alone, as the result of an effort to *recede*, counteracted by the *centralizing energy*, that the streams before us can at all be resolved into intelligible shapes: how fraught with interest then, the determination of the exact *curve* they follow,—that curve which is the *synthesis* or equilibrium of these forces. Towards problems of this kind, the way will be cleared, so soon as science shall possess the researches of Lord ROSSE: and already the lights they must cast on these obscure nebulæ, seem foreshadowed. For instance, compare, however generally, the apparent forms of the various spirals. Plate XV. is the true figure of 99 Messier—a mere speck as formerly known: observe the full and open sweep of its arms! These are manifestly bent into regular and definite curves; but place them beside the branches of the great Spiral of Plate XII. Can the eye rest on those objects, however briefly, without discerning that, in the system 99 Messier, the divergent tendency is relatively the more powerful; and is it doubtful, that a precise discrimination of the curves must reveal the nature of this relation? Again, examine the Spiral in our

frontispiece.* More closed, than even the great Spiral, —its arms, bent almost into circles, show a still more marked predominance or excess of the *centralizing energy*, and perhaps betoken the approach of the system to the riper phase of *completed rings*. Surely, it is more than fancy, which has indicated this singular *series!*

But, would I venture to restrain the freedom—the possibilities of Nature, within the terms even of such a series? Shall the marvels lying on the sides of our narrow pathway, limit the contents of these untrodden, unfathomable Spaces? It is not to be forgotten that the forces of which we have spoken are capable, by their interminglings, of evolving stellar arrangements of a variety far from being indicated by the phenomena yet recorded; witness on earth, the whirlwind and the comet's career, the tidal movements of the ocean, the direction of the mariner's needle—ay, and the secular course of its mysterious deviations! Although simple in their origin and primal relations, even *two* such tendencies may vary indefinitely in their *effective action;* for their ultimate or external manifestation

* This singular figure, as seen by Sir JOHN HERSCHEL, is represented in Fig. 4, Plate IX.,—another remarkable instance of the difficulty of concluding the true character of any of these objects from its appearance in smaller telescopes.

depends in every case on the forms and collocations of the masses over which they operate: Nebulæ, therefore, may be conceived under their government, not lying apparently between spirals and spherical clusters. But instead of speculating, let us rather rest in reverent contemplation of the vast prospect now below us! Is there an Imagination so lofty, that it may not be satiated by its majesty? Or what earnest man, searching through its wastes, may not find some new 'pebble' illustrative of universal Laws?—

SEE! ALL THINGS WITH EACH OTHER BLENDING—
EACH TO ALL ITS BEING LENDING:
ALL ON EACH IN TURN DEPENDING—
HEAVENLY MINISTERS DESCENDING,
AND AGAIN TO HEAVEN UP TENDING:
FLOATING, MINGLING, INTERWEAVING,
RISING, SINKING, AND RECEIVING
EACH FROM EACH, WHILE EACH IS GIVING
ON TO EACH, AND EACH RELIEVING
EACH, THE PAILS OF GOLD, THE LIVING
CURRENT THROUGH THE AIR IS HEAVING:
BREATHING BLESSINGS SEE THEM BENDING—
BALANCED WORLDS FROM CHANGE DEFENDING;
WHILE EVERYWHERE DIFFUSED IS HARMONY UNENDING!

THE foregoing pages are far from containing an account of all known systematic nebulæ. I have attempted simply to describe such as appear types of great classes, and therefore emphatic expressions of the laws which govern this august order of phenomena. Others there are in the meantime apart, but nevertheless of remarkable aspects: for instance, Sir JOHN HERSCHEL'S curious looped shape, the 30 Doradûs. The subjoined diagram will convey a rude notion of the appearance of this strange mass. There are correct

and delicate pictures of it in the two recent works of this Astronomer, who has well defined it generally as a nuclear centre, with environing loops and branches, like a 'true lover's knot.' Dr. Robinson has spoken, likewise, of objects seen at Parsonstown, resembling Saturn and his ring, which, if words in such a case were not so vain, one might imagine to be oblique views of Spirals, with an immense central globular mass.—But I must hasten to a totally different species of appearances.

It seems, by various notices from Lord Rosse, that small nebulæ are found not unfrequently, in singular proximity. Plate XVI. is an instance of this class of objects; and if we apply to such cases, the kind of reasoning which, in an after division of our volume, will be found fruitful of important consequences, we would infer the proximity to be *real*, and not apparent only; that it indicates besides, a *special system* among these masses—an internal mechanism probably—if not their common and comparatively recent origin, in the breaking up of a long stream of stars. Declining, however, to indulge in speculation on phenomena that promise a very abundant recompence to future inquiry, I must ask attention, in some detail, to objects which indicate a connexion among nebulous masses on a still grander scale. In the Heavens, alike in the northern and southern hemisphere, we have instances of nebu-

losities very widely diffused, some resolved, although with difficulty, and others yet defiant of the highest power applied to them; all, however, appearing to be extensive strata or beds of stars, and generally having within them *curdlings*, as they seem at first—separate massive clusters of various forms, evidently constituting part of some vast system whose domain is co-extensive with the diffusion of the nebulous light. In our northern skies there is one instance, at least, of this extraordinary formation—viz., the great nebula in the sword of ORION. As on other accounts I shall require again to speak especially of this magnificent object, at present I shall ask my reader to dwell for a moment only, on the representation of it in Plate XVII. No eye, I believe, ever rested on this mysterious mass, lying there so inscrutable, without an astonishment merging into awe! What can one make of those fantastic arms, —bays and gulfs unsounded attempting an inroad on vacancy; and through what unimaginable recesses of Space, might not Reason—judging by their varying shades of light—essay to track their career! And yet, although most hard to analyze, *that* is a stupendous association of orbs, filling what well might seem *Immensity*—with grand yet inferior clusters within its bosom, looking in one part, like the separate clouds of a mackerel sky, or those wisps of brilliant light which mottle the face of the Sun. Superb beyond conception,

but also most utterly bewildering, the aspect of this Nebula seen through the six-feet Reflector! Rare indeed and fleeting are the opportunities, but not many years can now elapse ere Astronomy shall be possessed of the greatest triumph of modern Telescopic power—viz., the map from Parsonstown of an object which so long has puzzled all observers.—In the South, a phenomenon somewhat similar meets us in two localities.

I. Amid the splendour of the southern Heavens, lie two small clouds, not so vivid as many quiet masses floating on the bosom of the azure of a summer's sky; but, unless in the brightest moonlight, they are always distinguishable; and in honour of an adventurous navigator, they have been named Magellan's Clouds. Instead of simple milky patches, or permanent light flocculi, as they seem to the spectator, these objects shone through Herschel's telescope, robed in inconceivable splendour. The inferior of them—the Nubecula Minor—having the same structure as its more prominent companion, I shall not again refer to it here: and with regard to the Nubecula Major, I shall not aim at more than a general sketch of its characteristics. The aspect of this nubecula to the naked eye, is something of an oval disc; and a telescope of ordinary power shows a bright band running across that disc. On closer inspection, the entire disc—the band more especially—

appears composed of multitudes of minor clusters in singular proximity: they are indeed so close and numerous that Sir John Herschel himself speaks of the riches of the cloud as defying representation. Referring to his volume for a detailed account of what he discerned, I shall ask attention, in the meantime, simply to the leading features of the nubecula. *First.* It lies quite apart—by itself—in the heavens. Surveys or sweeps from any portion of it into the neighbouring spaces, bring within the field of view of the telescope — instantly that its limits are overpassed — districts comparatively vacant, 'oppressively' devoid of stars. I do not know if this comparative *vacancy* has reference to the fulness of the general region within which, as a framework, the object has been set; but assuredly it discriminates its boundaries, and marks it out as a special and—if I may use the expression—an *extra-galactic* phenomenon. *Secondly.* The entire mass of the nebula sparkles with stars; from those nearest us, on its frontier, to magnitudes escaping apprehension even by the eighteen-inch reflector: for, as the Astronomer informs us, he left everywhere in the distance an *unresolved* nebulous cloud. It seems as if there lay in space, in volume immeasurable, a mass of stars, utterly irregular in general form—not unlike one of the great cumuli of the Milky Way, transported from connexion with that comparatively continuous zone. And amid

this amorphous mass we have clusters marvellous in number (somewhere about *three hundred!*) and often capricious in shape, 30 Doradûs being one; also of all degrees of resolvability, from that whose separate orbs are easily evoked, to others lying intractable—brighter patches on a milk-coloured canvas. Can this, indeed, be a separate 'Universe,' thronging with discrete clusters which is pushing one or *two* of its extremities near to us?

II. More wonderful still, that other memorable patch —the nebula in the Southern Argo. We have no knowledge of this extraordinary mass, beyond what Sir John Herschel has given us, to whose larger work I again refer. While following a gorgeous part of the stream of the Milky Way, wherein hundreds of stars are crowded into very minute spaces—suddenly a diffuse but strongly-marked nebulous Light, enters the field of the telescope, indicating no connexion with the stratum through which we view it, but, on the contrary, a substance—of whatever nature—lying far behind, among the remoter abysses. The apparent *face* of this nebula can be reduced within no intelligible form.* There is a central oblong but very irregular black or empty space, surrounded by a dense nebulous region of considerable

* See the large engraving in Sir John Herschel's quarto volume, or a fine reduction of it in his 'Outlines of Astronomy.'

breadth; and in the neighbourhood, fainter beds lie scattered of various fantastic shapes, between which and the principal mass dim branches can be traced. But *shape* in this case is not the feature which attracts us. Contrary to what we have remarked — alike in the nebula in Orion and the clouds of Magellan—not a star is visible within the region of Argo, nor any special *mottling* indicative of separate clusters. Unless, therefore, the telescope which explored it, has overlooked such *discreteness*, we must suppose it a huge accumulation of uniformly scattered stars at a remoteness which now is immeasurable. Further speculation were here perhaps as easy as profitless; but all temptation to indulge in it is removed by the auspicious fact that our great Scientific Association has—at the suggestion of its eminent President — requested the aid and concurrence of Government, towards establishing at the Observatory of the Cape, one of those immense instruments which have already accomplished so many unhoped-for analyses in our Northern heavens. The results must be invaluable to Astronomy; and to the distinguished Society which suggested it, assuredly the proposition is most honourable.

Among the considerations pressing for notice, regarding these gorgeous objects, one alone of chief import remains. After the mind has mastered the august conception that the general starry system is a scheme of separate galaxies, the question springs up as to their probable distances from each other, or the probable depths in space at which they respectively lie. The idea of actually *charting* these profound regions was especially accordant with the genius of Sir William Herschel; and he saw reason to undertake it at an early epoch, when he laid down the principles by which alone it will ever be accomplished. Of the circumstance chiefly constituting the penetrating power of a Telescope I have already spoken; but we may easily reach a few propositions more definite and applicable. The capacity of the eye for *light* depending on the size of its pupil, and that of the telescope, on the magnitude of its reflecting disc or refracting lens,—one sees without difficulty how any telescope may be compared, as to power, with the eye.

Light, it is true, is always *lost* in considerable quantities during the process either of reflection or refraction; but as the amount so lost can be determined by experiment, we are not thereby rendered unable to say—in any given case—how far the range of a telescope ought to exceed that of human vision. The estimates made by HERSCHEL in regard of his own telescopes were the following:— His ten-feet telescope, with a mirror of nine inches in diameter, he considered of the space-penetrating power 28½; *i. e.*, it could descry a star or any object twenty-eight and a half times farther off than the naked eye can. To one of his twenty-feet reflectors, he assigned a power of 61; and to another of the best construction, with a disc of *eighteen inches*, the power of 96. The space-penetrating power of his greatest instrument, being the forty-feet telescope, with a reflector four feet in diameter, he settled at 192. I suppose it is now generally understood, and surely the fact can detract nothing from the merits or the fame of this illustrious man, that HERSCHEL'S greatest telescope was comparatively of little avail in research, because of defect in its defining power, or in its *figure;* but it is not easy to suppose that simply as a *light-grasper* its efficiency is overstated in the previous estimate. Lord ROSSE'S instruments are of a different metal from HERSCHEL'S; and, by aid of the mechanism he planned for them, they are endowed with the highest polish. The three-feet disc—though we

cannot in the circumstances of the case reach a precise conclusion—appears superior in space-penetrating power to the great instrument of HERSCHEL; and if that is correct, it is not possible to suppose the efficacy of the six-feet mirror less than *five hundred times greater* than that of the eye; in other words, it would show, as clearly as the heavens shine to us on a cloudless evening, the details of a starry universe, stretching into space five hundred times farther than those depths at which we gaze in silence—as if already on the confines of the INFINITE!

—We must now take into account another very simple set of considerations. It appears that the unaided eye can see a star about twelve times farther off than the average of stars of the first magnitude: *i. e.*,—speaking generally and with care not to exaggerate — at a distance from which light cannot travel to us in less than one hundred and twenty years: we should expect, therefore, that the six-feet mirror penetrate so profoundly into space that no single star could escape its scrutiny, unless at a remoteness which would occupy light in overspanning it more than *sixty thousand years.* Depths that are indeed astounding; but let the incredulous reader—remembering the beautiful illustration of ADDISON—quietly ask himself, how *little* would appear to be immeasurable before the eye and intellect of an Insect?—Our next step in this inquiry involves an hypo-

thesis, but only the hypothesis we have carried with us all along. It is, that as in the heavens environing us, so, with regard to these clusters, we may suppose the stars of an average magnitude, or, what is the same thing, issuing an average amount of light. This permitted, we can quite ascertain the comparative remoteness of all *resolved* clusters; for, so soon as their individual stars become visible, the size of the telescope resolving them is the measure of their distance in space. A cluster, for instance, resolved only by an instrument whose penetrating power is 96, must, if our assumption have any foundation, be so far off that its light cannot reach us in less than twelve thousand years. Singular *tape*, with which to mete these spaces! But any unit will serve as a means of comparison; and on the grounds I have explained, this one may enable us to construct the stupendous chart. The principle made use of in the case of *resolved* clusters, HERSCHEL conceived also applicable through analogy to groups not unfolding their individual constituents: and he computed that by his four-feet mirror a cluster of 5000 stars might be descried as a milky spot, although three hundred thousand times deeper in space than SIRIUS probably is!

In the existing state of Inquiry, it would be folly to venture farther. But with all our knowledge, where are

we—although at the centre of a sphere, whose circumference is thus inconceivably remote? Beyond it, is Infinitude, boundless as ever! We have made a step indeed, but, in truth, only towards acquaintance with a new order of *Infinitesimals.* In our earliest conceptions, the distance of the earth from the sun is a quantity beyond limiting: compare it with the intervals between the fixed stars, and it becomes no quantity at all, but only an infinitesimal; and now, when the spaces between the stars are contrasted with the dread abysses separating those firmaments, they absolutely vanish below us. May not even that entire arrangement of galaxies be, in its turn, only a corner of some mightier scheme, like our solar system amongst the myriads of fixed stars,—a repetition—on an increased scale—of the group composing the Nubecula Major of the south, or, *a mere nubecula itself?* Probably COLERIDGE is not in error: 'It is surely not impossible, that to some infinitely superior Being, the whole Universe may be as one plain—the distance between planet and planet being only as the pores in a grain of sand, and the spaces between system and system, no greater than the intervals between one grain and the grain adjacent!'

But let us not go on to bewilderment. Apart from considerations of space and time, we know this fact, that we are in the midst of BEING whose amount, perhaps,

we cannot estimate, but which yet is all so exquisitely related, that the perfection of its parts has no dependence on their magnitude,—of BEING, within whose august bosom the little ant has its home, secure as the path of the most splendid star, and whose mightiest intervals —if infinite Power has built up the framework—infinite Mercy and infinite Love glowingly fill, and give all things warmth, and lustre, and life—the sense of the presence of GOD!

Those melodies — that voiceful infinite!
And yet they call it — *Silence!*

CHAPTER III.

THE SPECULATION CONCERNING A NEBULOUS FLUID. EXTENT OF THE VISIBLE SIDEREAL UNIVERSE.

IT was while contemplating the subject discussed in last chapter, that Sir William Herschel yielded to a speculation as remarkable as any of so high a nature to which modern times have given birth, and which has exercised accordingly much influence over the tone of subsequent thought. I refer to his theory of a nebulous fluid, founded on certain peculiarities of some of the unresolved nebulæ, which induced him to imagine that many of these milky spots are not remote galaxies, but, on the contrary, accumulations of a shining fluid akin to the cometic, and probably located at no great remoteness, amid the interstellar intervals of our own heavens. The grounds of this supposed distinction, even though by deeper insight they have now been found to be fallacious, were not of a nature to discredit the sagacity of this extraordinary man; and his deductions, which grew into a splendid scheme of the genesis of the universe of stars, are memorials, not to be forgotten, of

a spirit that—with humility unabated, and ever-deepening reverence—could rise of its own accord to the contemplation even of the beginning, progress, and probable close of these stupendous material arrangements.

Such a fluid—supposing it to exist—could not, it is evident, be distinguished from unresolved clusters of stars, either by the nature of its light, or the simple fact of its irresolvability; for, while the illumination transmitted by it would in all probability be dim and milky, similar in every respect to that which reaches us from remote galaxies, the mere attribute of *irresolvability* could be of no avail in enabling us to separate it from other objects equally unresolved—resisting with equal obstinacy the highest telescopic energy. Masses of such a fluid, and unresolved clusters, would indeed entirely correspond in their external features; nor could they well be discriminated, unless—through their *neighbourhood in the sky*—we had the opportunity of detecting a contrast or discrepancy in some *essential*, though in appearance *minor* attribute. And it was in the following way that HERSCHEL became persuaded of the reality of such a discrepancy. I have referred already to that curious order of clusters formerly termed NEBULOUS STARS. To telescopes inferior to those of Lord ROSSE,—such as alone were at the command of his immortal predecessor, —the clusters in question appear, as I have said, *like*

stars enveloped in circular halos; perfectly pure and definite luminaries, engirt by a cloudy or cometic envelope. Nor could HERSCHEL doubt the reality of the *connexion* between the apparent star and its luminous atmosphere, for the bright point occupied always the *centre of the halo*—an arrangement which, in such frequency, could not possibly occur by chance, or be explained on the hypothesis that two bodies not connected, were always to be found lying so symmetrically along the same visual line. A *physical* connexion between two objects apparently so diverse being accepted accordingly, the question arose, what can be the relation between these objects? what theory will account at once for star and halo? 'In the first place,' says HERSCHEL, speaking of a case in which the star was of the eighth magnitude, 'if the nebulosity consists of stars that are very remote, which appear nebulous because of the small angles their mutual distances subtend to the eye, whereby they will not only as it were run into one another, but also appear extremely faint and diluted, then what must be the enormous size of the central point, which outshines all the rest in so superlative a degree as to admit of no comparison! In the next place, if the star be no bigger than common, how very small and compressed must be those other luminous points that are the occasion of the nebulosity which surrounds the central one! As, by the former sup-

position, the luminous central point must far exceed the standard of what we call a star, so, in the latter, the shining matter about the centre will be much too small to come under the same denomination; we therefore either have a central body which is not a star, or a star involved in a shining fluid of a nature totally unknown to us. I can adopt no other sentiment than the latter, since the probability is certainly not for the existence of so enormous a body as would be required to shine like a star of the eighth magnitude, at a distance sufficiently great to cause a vast system of them to put on the appearance of a very diluted milky nebulosity.' Let the position of HERSCHEL, when he accepted this conclusion, not be misunderstood. In presence of a phenomenon wholly unlike any other previously noticed and analyzed, he places before himself an alternative—he is between the only two explanations which any analogy from established facts could suggest; and of these he certainly chooses the most likely. The first explanation —viz., the supposition of an enormous central body—is indeed recommended by no considerations of probability; for if such bodies had existed, the chance was that we would have had it in our power to recognise them in positions affected by no ambiguity; while the second is pressed by no such difficulty, for, in the first place, supposing the nebulous fluid to exist, it could manifest itself nowhere otherwise than as a sparse shining mass;

and, besides, such a substance *is* known to exist, and is closely interlaced with the system connected with our sun. The ZODIACAL LIGHT, for instance,—a bright cone projected on the sky, in certain seasons, after our luminary has set,—may easily be supposed to belong to this modification of matter; and the same important fact is indicated by the COMETS—those masses of a substance so essentially ethereal, which rush towards us, from all quarters of the heavens, and thus indicate the wide diversity and diffusion of their seats.

Before passing onwards, I would rest for a moment, and review the great Nebular speculation of HERSCHEL. Considerations I shall afterwards speak of, appeared to join with the foregoing reasoning, and to sustain his belief in a formless, chaotic, dimly luminous mass—widely diffused through the heavens. At no large distance could a substance, so thin and discrete, be visible; therefore, from the masses of it, which without great difficulty we discern, its immense extension through space—especially along its depths—might be *inferred*. What, then, the function of such a substance?—what its place amid this vast economy? In the first place, HERSCHEL applied himself to the arrangement of its different outlines and apparent structure. He saw it, or seemed to see it, in many places, *chaotic:* it had *there* no intelligible figure, or intelligible manifestation of structure;—it was form-

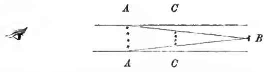
less and void. Then, in the midst of other masses, seemed a gradual alteration of this amorphous form—the constitution of *nuclei*, around which the matter appeared congregating. The investigation of the character of these nuclei was the subject of another and still more remarkable inquiry. It occurred to our Astronomer that they showed throughout, the efficacy of a *clustering* or *concentrating* power; and he classified them according to a gradation, of which Plate XIX. is no over-refined expression. But the progress did not terminate with the ulterior forms in that Plate. Farther onward, condensation seemed to proceed: the solid yet diffused centre merging into a star amid a halo;—the halo itself gradually shrinking into a *bur*, or an atmosphere around a star, of the kind of our zodiacal light.

THE facts which have invalidated HERSCHEL'S conclusion in the foregoing circumstances, were not known to him, and he did not suspect their possibility. It did not occur to him that his 'star of the eighth magnitude' might in reality be a *group of stars*, blended by distance into the appearance of a single orb; and the entire object—star and halo—only one unresolved cluster with *remarkable concentration at its centre.* It is true, that very few of our resolved spherical nebulæ could, through effect of increased distance, undergo an apparent transformation of the foregoing kind. For instance, Plate V. shows the same nebula as seen by two different telescopes—Lord ROSSE'S three-feet mirror, and Sir JOHN HERSCHEL'S, whose diameter is only half that size. Now, if the object revealed to the large mirror, were, while under its gaze, withdrawn into remote space, it would not merge towards

a star and halo, but simply to the form of figure 1; and this again—the object being farther withdrawn—would become a circular spot of diffuse and faint illumination ere it altogether disappeared.—Before it could become a star and halo in the distance, the internal constitution of the nebula would manifestly require to undergo a great internal change—viz., there must supervene a vastly *stronger compression of its central stars.* These, indeed, are already so much compressed, that the overhead sky, seen from the interior regions of the cluster, must appear gorgeous beyond conception. But the degree of concentration needed to enable them to look like a single star of the eighth magnitude to HERSCHEL's instruments, while the rest of the cluster seemed only as a halo, is incompatible with their present constitution; nor has it any likeness amid all the variety around us. To our astronomer, then, the supposition that the central object on which he reasoned was not in reality a star, led only towards a new improbability, an exception of another kind to the order of surrounding arrangements; and what wonder was it, though even he who had clomb heights so lofty, and passed unbewildered through many untracked lands, should yet, in presence of a phenomenon portending schemes of Being wholly unknown and utterly dazzling, have felt his imagination enfeebled in daring, and thereupon assumed as a refuge the easier and more probable hypothesis

of a self-shining fluid, whose existence would veil the variety and temper the glories of this overpowering universe!

But I must dwell farther on this subject of *probable compression;* a clear apprehension of its significance and relations, being needful towards the understanding not only of HERSCHEL's argument concerning the nebulæ, but also of the revelations recently effected in reference to the sidereal arrangements, by what I cannot hesitate to term the most distinguished achievement of telescopic power. Let us take the assistance of a diagram. Suppose that the four stars at *A* are sufficiently distant from each other to be seen apart, and that they are at the *utmost limit of visibility* in regard to the naked eye—in other words, that they appear of the sixth or seventh magnitude. Now, it must be evident that if they were brought into *actual contact* with each other, or *compressed as closely as possible*, they would seem *one star* of four times the brightness of any of them separately; and we know from the laws of the diffusion of light, that this



composite body might be carried twice as far away into

space before attaining the boundary of *its* visibility. The four stars, separately on the point of disappearing at A, might thus by the extreme of compression be made to continue visible as far off as B; but, carried beyond B, they would be wholly invisible to the naked eye, for by no arrangement could they be made to give out greater light than would issue from them in the case I have supposed. Now, the space between A and B is a peculiar one with regard to these stars: it is the space within which, though individually invisible, they might yet appear as a *nebula or milky spot;* and the particular point in the line $A\ B$ at which they would just be seen as a nebula would evidently depend on the *degree of their compression.* If, for instance, they were *nearly* compressed into one star, they would be visible as a nebula, almost as far off as B; and if they were only slightly compressed, forming a *coarse* nebula, they would not be seen as such much farther off than A:—nay, speaking in general terms, I may state, that the distance from the eye at which these four stars could be descried as a nebulous spot would be the point at which—because of the amount of their compression—they would just fill up a section of the triangular space in the preceding woodcut:—if compressed so as just to occupy the section indicated at C, then they would be first visible, *as a nebula*, at that degree of remoteness.—

I am persuaded that I hazard nothing, if, now assuming it as established, that the farther off any set of stars are, which are visible as a nebula, the more compressed must they be; so that if one knows a limit of distance within which a certain body of nebulous aspect cannot lie, an opinion may be formed of the *degree of compression* necessarily belonging to it. Now, in the course of his unequalled experience, the great Observer whose steps I am following, had examined the structure of many clusters—not in their outline merely, but their internal constitution; and analogies from them all, seemed to impress him with the feeling that in these gigantic groupings of stars there is a certain 'order or uniformity of nature,' an amount of individual separation especially, which, it might be, was requisite to secure an independent existence and unincumbered functions to each constituent orb. But there came before him a class of objects, of which this 'order,' this usual degree of compression, could in nowise be asserted. There were nebulæ easily seen, whose resolution defied the highest powers even of his telescopes; and as this latter circumstance enabled him—on the principles explained at the close of last chapter—to throw them back into space beyond a certain limit of distance, in itself enormously remote, the difficulty as to their constitution presented itself in the following form:

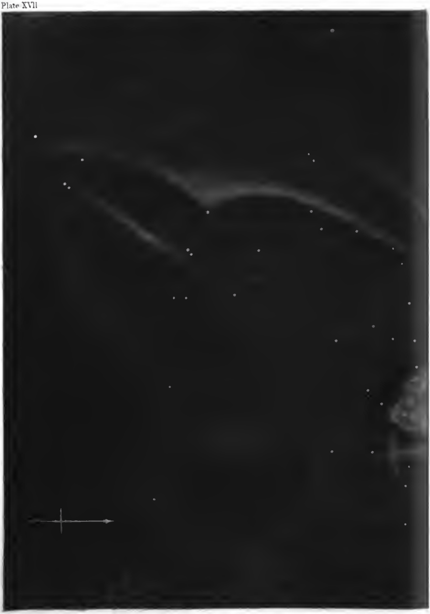
Can these mysterious masses indeed consist of stars so compressed — compressed beyond all comparison,—or, rather, are they not objects of a different kind—masses of a diffused luminous fluid, and not clusters of stars? The conception suggested first by the nebulous stars was thus reproduced with increase of vividness; and HERSCHEL became confirmed in his inclination to avoid the idea of a disposition of orbs most strange and absolutely new—not, indeed, because such dispositions are in themselves impossible, but because in the existing condition of his knowledge and experience, it appeared *to violate analogy less*, to suppose that the cometic matter, even in stupendous masses, is not foreign to the interstellar spaces.—Let me turn, however, from these general considerations to the special history of one great nebula—that in the Sword of ORION. The naked eye almost discerns this extraordinary object. On examining the middle star in the Sword, it appears affected by an indefiniteness not common to small stars; and the application of the smallest telescope unfolds at once the cause,—the seeming star being converted into a diffused haze. Examined with instruments of a profounder space-penetrating power, its character as a haze continues unchanged, though it speedily manifests the features of some strange and fantastic object. To the ten-feet mirror, for instance, which was estimated by HERSCHEL to descry a single star three hundred and

fifty times farther away than the average distance of orbs of the first magnitude, it looks like a shapeless mist, something as below:—

But not a vestige of a star is discernible; and yet, be it observed, the light from that object affects the naked eye, although—being intractable to the foregoing telescopic power—it may lie so profoundly in space that the ray leaving it must travel some four thousand years ere it could reach our world. It is little wonder that, even *then*, the nebula of ORION seemed inexplicable! Apply now Sir JOHN HERSCHEL'S eighteen-inch mirror. Not yet the remotest trace of a stellar constitution, but the object so frequently figured in astronomical works —an object of which the revelation of the ten-feet telescope is evidently the mere rudiment. Strange indeed those fantastic branching arms, but not less strange the apparent internal constitution of that extraordinary mass! So unaccountable seemed it, and so unlike what had hitherto been known of collections of stars, that the eminent astronomer who sketched it did not scruple to

aver, that so far from showing a trace of stellar constitution, or even suggesting that, it rather suggested something quite different: he had not then, indeed, seen the scroll nebula of Lord ROSSE, whose broken and irregular mass removes improbability even from the most strange idea, that stars wholly compose those wisps near the mouth of the mass in ORION. That drawing by Sir JOHN, however, was only our first introduction to the more capricious irregularities of this gigantic and extraordinary meteor. During his three years' fruitful residence at the Cape of Good Hope, he employed his accurate pencil in executing a drawing of the nebula as it appeared through those skies; and although the telescopic power employed in the latter case, was no greater than in the former, the skies through which it had to traverse are incomparably clearer; and ORION, which is low with us, and affected, therefore, in most cases, by the mists of the horizon, is, when it crosses the meridian, but a short way distant from the zenith at the Cape. HERSCHEL'S drawing is in his great work: but I give another, remarkably corresponding with it, to which also a farther interest is attached. The figure I refer to is one of the earliest contributions of the great Refractor of the University of Harvard, in Massachussets — an earnest alike of the skill of Mr. BOND, and of the efficiency of another triumph of MUNICH optical art—one which yet has no equal, save in the companion glass at

Plate XVII



GREAT ...

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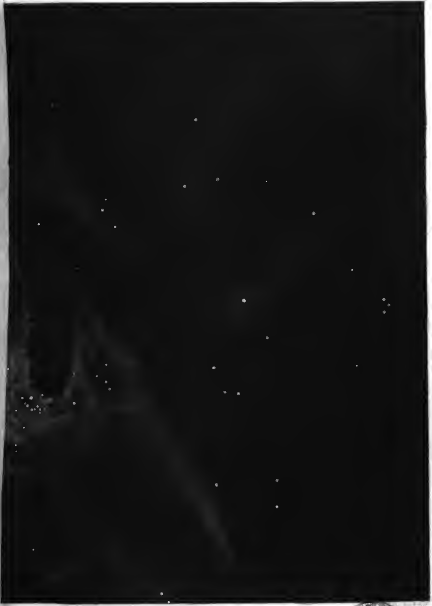

A OF ORION

Refractor

Poulkova. Surely the nebula, as there revealed, can be the object only of unmingled wonder! Inexplicable to the instructed as to the uninstructed eye,—both must gaze on those inextricable branches and windings—those cloudy masses thinning off into the veriest shadows of being—or those other bright but comparatively isolated patches, lying, as it were, on the shore of absolute blackness: yes! forms so mysterious none can contemplate, save with silent amazement! The multitudes of smaller stars, seen in the same field of view, are evidently much increased by the Harvard Refractor; but Sir JOHN HERSCHEL records that the nebula, through his Reflector, shows not a symptom of resolution. If a cluster, therefore, it is so remote that its individual stars baffled his pursuit even through those southern skies; so that we must pursue it across depths yet more profound, ere the veil shall be raised which shrouds its constitution. Mr. LASSELL, of Liverpool, whose name is now a sure guarantee for all care and sagacity, and which is already impressed ineffaceably on scientific history, has interrogated the same nebula with his two-feet Reflector; but though that enabled him to execute a remarkable drawing, not even his researches offered the glimmering of a hope. One other effort followed, more promising than the others, but still without definite success. The three-feet mirror of Lord ROSSE, more powerful, of course, than Mr. LASSELL'S, was, during the winter of 1844-5,

directed to that unintelligible mass; but, notwithstanding his Lordship's penetration, he could discern nothing entitling him to declare the constitution of the nebula to be stellar. Yet, if it be composed of stars like those around us, that great mirror ought to have detected them, had they been separated from us by no more than an immensity through which light could travel in some *thirty thousand* years! And, be it not forgotten, the mass thus remote is *visible to the naked eye!* Surely we may again exclaim that the loftiest imagination might shrink without reproach from the admission of facts like these—from belief in a *System of Stars* so majestic, of splendour so concentrated, as on the supposition of its being stellar, we must attribute to that mass!

I approach the final resolution of all these doubts—our last grand step in investigating the glory of these heavens. Strongly attracted in youth by the lofty conceptions of HERSCHEL, I may be apt to surround the incident I have to narrate, with feelings in so far of a personal origin and interest: but, unless I greatly deceive myself, there are few who would view it otherwise than I. With an anxiety natural and profound, the scientific world watched the examination of ORION by the SIX-FEET mirror; for the result had either to confirm HERSCHEL's hypothesis, in so far as human insight

ever could confirm it—or unfold, among the stellar groups, a variety of constitution not indicated by those in the neighbourhood of our galaxy. About Christmas, 1845, I was at Parsonstown, and saw the nebula through the mighty tube. It was—owing to the incompleteness of the instrument and unfavourable weather— the first time that the grand telescope had been directed towards the mysterious object; and although Lord Rosse warned me that the circumstances of the moment would not permit him to regard the decision then given as absolutely final, I went in breathless interest to its inspection. Not yet the veriest trace of a star! Unintelligible as ever, *there* the nebula lay; but how gorgeous its brighter parts! How countless the streamers now branching from it on every side! How strange especially, that large horn on the north, rising in relief from the black skies like a vast cumulous cloud! It was thus still possible that the nebula might be irresolvable by human art, but doubt manifestly remained. Why the concurrence of every favourable condition is requisite for success in such inquiries, may be readily comprehended. The object in view is to discern *singly*, sparkling points small as the point of a needle, and close as the particles of a handful of sand; so that it needs but the smallest unsteadiness in the air, or imperfection in the shape of the reflecting surface, to scatter the light of each point, to merge them into each

other, and present them as one mass. Knowing his Lordship's intention to avail himself of all favourable opportunities during winter—after regrinding the great mirror—to penetrate, if possible, the constitution of this wonderful object, I anxiously awaited fresh intelligence. At length I received the following memorable note:—

'Castle, Parsonstown, March 19, 1846.

'In accordance with my promise of communicating the result of our examination of ORION, I think I may safely say, that there can be little if any doubt as to the resolvability of the nebula. Since you left us, there was not a single night when, in absence of the moon, the air was fine enough to admit of our using more than half the magnifying power the speculum bears: still, we could plainly see that all about the trapezium is a mass of stars; the rest of the nebula also abounding with stars, and exhibiting the characteristics of resolvability strongly marked.

'ROSSE.'

And thus doubt and speculation disappeared from this great subject for ever! The resolution of the nebula of ORION into stars, proved that to be REAL, which, with conceptions of creation enlarged even as HERSCHEL'S, we deemed INCOMPREHENSIBLE; and has shown that the laws and order of existence, on its grandest scale, cannot be

safely imagined to be exhausted among the processes and phenomena around our homes. Yes! the Infinites we build up after the fashion of what is familiar, shrink, as the ages advance, within limits again—Idolas sufficing for an epoch, but filling neither space nor time. And from inner Adyta—the invisible shrine of what alone is and endures—ever and anon the appeal is heard, 'Hast thou an arm like God, or canst thou thunder with a voice like Him? Gird up thy loins and declare! Canst thou bind the sweet influences of the Pleiades, or loosen the bands of Orion? Canst thou bring forth Mazzaroth in his season, or bind Arcturus with his stars?'

It has been asked sometimes by persons who have only in so far followed this remarkable history, why should a conception so far-extending as Herschel's be liable to overturn from the resolution of a single nebula? Are not many such masses in the heavens still irresolvable even by the great mirrors of Parsonstown? It cannot, indeed, be doubted that nebulæ, defying the most energetic of these instruments, are to be found in numbers in the sky; nay, there is one especially, exceeding even Orion in easy visibility—viz., the strange mass in the girdle of Andromeda, which has probably not yielded to the six-feet telescope; but,

nevertheless, every shred of that evidence which induced us to accept as a reality, accumulation in the heavens of matter *not stellar*, is for ever and hopelessly destroyed. The logical state of the question is simply this: on the ground of a certain characteristic, HERSCHEL felt disposed to divide unresolved nebulæ into two classes; he declined to believe one class to be stellar, because that conclusion would have constrained his acceptance of what seemed opposed by all analogy—viz., the existence of aggregations of stars in a condition of *compression* to which he had found nothing even approximately similar, in the course of his previous examination of the universe. Now, the nebula of ORION being an eminent instance of this latter class, its decisive resolution broke down the force of the characteristic on which HERSCHEL depended as a discriminating one: it showed that to be a *fact*, on the presumed *improbability* of which, the entire theory depended. Assuredly, it is not impossible that matter may be found somewhere in a rude or chaotic state—not having yet put on the organization of stars. To the abstract possibilities of existence no man dare assign any limit: but what alone is existence or reality for the mind—the domain of its belief—is guarded by strict rules of evidence; and *now* the astronomer can adduce no justification of the assertion, that any nebula, however stubborn, ought to be interpreted contrary to the analogy of all other known objects of its kind, or termed

irresolvable, except in relation to the capacity of the telescope with which he had sought to explore it.

Of the resolution of the mass in ORION no doubt whatever can remain; for subsequent examination has confirmed in all respects the first emphatic impression of Lord ROSSE. The extraordinary object has not yet been satisfactorily sketched; so that we can speak only from report of its unparalleled marvels; nor is much more known than the fact, that the *mottled region* forming the brighter part of the mass, is a very blaze of stars. In regard of the stellar creation itself—now that we are freed from all dubiety concerning the significance of those hazes that float numberless in space — behold every one of them, every speck however remote or dim, a noble galaxy! Lustrous, too, in many cases, beyond all neighbouring realities—beyond the grasp of even an exercised imagination. The great cluster in HERCULES is most superb to the eye; but we have learnt now that among circular and compact galaxies—a class to which the *nebulous stars* belong—in respect to its central glories, even this one may not be far from the *lowest point;* and that schemes of being rise above it—sun becoming nearer to sun, until all their skies are one blaze of light—a throng of burning Activities! But aloft, above all, stands ORION—the pre-eminent glory and wonder of the starry universe! Judged by the only criticism yet appli-

cable, it is perhaps so remote that its light does not reach us in less than fifty or sixty thousand years; and as, at the same time, it occupies so large an apparent portion of the heavens, how stupendous must be the extent of the nebula! It would seem almost, that if all other clusters hitherto gaged were collected and compressed into one, they would not surpass this mighty group, in which every wisp, every wrinkle, is a SAND-HEAP of stars! There are cases in which, though Imagination has quailed, Reason may still adventure inquiry and prolong its speculations; but at times we are brought to a limit, across which no human faculty has the strength to penetrate, and where, as now—on the threshold of the very Infinite—we can only bend our heads, and silently ADORE!

In the course of the preceding discussions, allusion has been frequent to the remotenesses with which we must endow objects, whose depths in space are estimated only by consideration of the magnitudes of the telescopes that analyze them. From the nature of the case, numerical statements deduced on such grounds cannot be supposed to possess other than a very general accuracy; nor have I presented them, except as approximations capable of showing us the *scale* according to which the material universe has been constructed. But before quitting the present division of our subject, I must advert to two classes of speculations recently spoken of among men of science, which go to invalidate utterly all admeasurements of this description, and would cast us back, in regard of the entire class of questions, among uncertainties not to be disentangled.

I. I shall examine, in the first place, a doctrine

broached some years ago by the illustrious Olbers, and recently impressed, with his distinctive animation, by M. Struve; a doctrine which may be termed the theory of the 'Extinction of the light of the stars.' Its fundamental idea is this:—Among the celestial spaces, some medium is probably diffused not absolutely transparent, but which absorbs a portion of every ray of light that passes through it. I shall not enter here into discussions of the technical part of the theory; suffice it, that by absorption, a body, however bright its nature, must if removed from us, diminish in apparent size, much more rapidly than it would do through mere effect of its distance; and therefore it would sooner disappear alike to the naked eye and the telescope:—on which account the limits of the visible universe must be greatly narrower than we imagined them, and indeed all our previous ideas of stellar distance must be erroneous by excess. The arguments in favour of this peculiar hypothesis are not exclusively of a *physical* kind; and they appear connected with astronomical phenomena only at two points. First, M. Struve claims support for his conception, from the numbers of stars seen by Sir William Herschel, while effecting those memorable 'gages,' by whose means he first thought of detecting an accurate *section* of our galaxy. It will not have escaped my reader's recollection that the relative distances of the stars down to the ninth order were fixed

by the Poulkova astronomer on the supposition that they are equally distributed through space: on reviewing the numbers recorded by HERSCHEL, he naturally asked therefore, *how large a sphere is requisite to contain these numbers*,—holding always by his first hypothesis? Now, he easily ascertained that a sphere sufficient for all that HERSCHEL had seen, need surpass in depth the region through which the eye can penetrate, not more than twenty-five times: but the optical considerations I have already referred to, bestowed on the telescope which HERSCHEL employed, a power three times larger, or of *seventy-five*. Whence, then, the contradiction? Why did an instrument which ought to have a penetrating power of *seventy-five*, not apparently reveal the contents of a sphere of a larger radius than *twenty-five?*—No doubt the discrepancy could be accounted for by the theory of '*Extinction*.' The optical power of such telescopes being computed on the hypothesis of an untroubled transparency of the celestial media, it is easy to see that if on the contrary these media are absorbents of light, the virtual or effective reach of a telescope can never approach its hypothetical one: but in my apprehension there is a consideration with prior claims, of which M. STRUVE has not taken sufficient account. The precise difficulty, be it observed, is this: the number of stars seen by HERSCHEL could not—on the hypothesis of uniform distribution—fill a sphere of radius seventy-

five, but only a sphere of twenty-five: assuredly, therefore, the first question to be answered is akin to the following:—In the remote spheres amid which our great observer was then, first of mankind, travelling, *can* we assert that *there is an equable distribution of stars?* It might be alleged, indeed, even before raising this latter inquiry, that HERSCHEL could not have reckoned all the stars in those fertile regions,—that when estimating those cumuli, those clouds of luminaries which compose the Milky Way, multitudes in every district must have escaped his apprehension, wonderfully active and susceptible though it was; but as M. STRUVE has not shown himself anywhere insensible to this source of error, I pass it in the meantime by. In illustration, however, of the *kind* of regions with which every instrument of great power must be supposed to have to deal, I must ask my reader to fancy the observer transferred to the interior of the central group of the great spiral of Plate XII. Narrow indeed the range of which he could justly predicate 'equable distribution!' Emerging from the spherical central clustre, his telescope would find itself amid comparative vacuities—having entered them almost suddenly; and not until again it arrived at the nearest of those engirdling branches would compression or abundance of stars reappear in its field. Less in degree, perhaps—though of this we are not certain; but assuredly similar in kind are the irregularities of the special domain

of our Milky Way. Immediately beyond its nearest stratum, we encounter great vacuities—intervals dividing its groups or streams, in which there are comparatively few stars;—and as Herschel himself laid down as the consummation of his experience, 'the gages there, do not enable us to sound *depths* by ordinary rules founded on the numbers of the stars, but rather to unfold *densities*, or the laws according to which that zone or the succession of zones appears to be constructed.' No man, indeed, may reject lightly any opinion of M. Struve's; but it is altogether impossible to conceal, that *irregularity* is to a large extent the law of these remoter portions of our galaxy.—But, secondly, we are not confined in this case to a mere negative argument. Keeping in view the peculiar structure of the Milky Way, recollecting that the telescope, in passing through it, often goes *by leaps* from one cumulus to another behind it, have we reason to deduce from phenomena, that any impenetrable veil withholds from us its recesses? I believe, quite the contrary. In every region where the stratum is prolonged, stars rise from the darkness on the application of an increase of power, in multitudes as overwhelming as the united considerations of distance and uniform distribution can require them: I mean, that wherever the object at which we are gazing advances with comparatively little interruption into farther space, the telescope pursues it unchecked, and there is nothing of that paucity

of stars, which M. STRUVE has quoted as characteristic. 'We are not at liberty,' says Sir JOHN HERSCHEL, in that recent valuable gift to the student—his *Outlines of Astronomy*—'we are not at liberty to argue that at one part of its circumference our view is limited by a sort of cosmical veil which extinguishes the smaller magnitudes, cuts off the nebulous light of distant masses, and closes our view in impenetrable darkness; while at another we are compelled by the clearest evidence telescopes can afford, to believe that star-strewn vistas *lie open*, exhausting their powers, and stretching out beyond their utmost reach, as is proved by the very phenomenon which the existence of such a veil would render impossible, viz., the infinite increase of number and diminution of magnitude, terminating in complete irresolvable nebulosity.' —p. 538.

II. We are met, however, by another difficulty: one still more effectively negativing all attempts at computation of distances, because, carried to its possible conclusions, it forbids our inferring whether a shining particle in the field of the telescope is a star, as we used to judge of such bodies, and not perhaps something liker a mote in a beam of the sun. I refer to the difficulty as to the *actual magnitudes* of the stars. I have said already, that the stars in our neighbourhood are not of one magnitude,—on the contrary, they vary considerably: but as

the phenomena of the skies immediately around us accord very closely with the doctrines of equable distribution and average size, we cannot in these regions question the general accuracy of either hypothesis. But the question remains as to the *external clusters*. Unless the orbs constituting them are of the average magnitude and intrinsic illumination of the bodies which occupy our heavens, we evidently cannot deduce their remoteness from the character of the telescope that first discerns them apart: nor, indeed, if there is a special size peculiar to each nebula, could we by such methods acquire the most imperfect knowledge as to their position in space. Undoubtedly a few curious phenomena recently observed, are not consistent with the idea that in this particular these remote regions are defective in variety. For instance, the circular and elliptic clusters which show great brilliancy at their centres, often consist of a central mass of comparatively *large* orbs, while those constituting the other portion of the nebula are less distinguished: and Dr. ROBINSON mentions a curious feature in the splendid cluster 46 MESSIER. The stars in this case are large and brilliant, and therefore probably not very remote; but *within the mass* is a planetary nebula or round disc, entirely composed of minute blue stars. Now this object is not encroached on by the larger stars of 46 MESSIER; it lies, as it were, within a circular cavity; and it is wholly impossible to suppose

that the objects are not in reality connected. Here, then, *are two contiguous masses, composed of stars greatly differing in magnitude;* and more examples of the kind may be found. In the work just referred to, Sir JOHN HERSCHEL has suggested a fresh difficulty having the same tendency—viz., the grouping within a space apparently limited in profundity, of objects of all degrees of resolvability—reference being especially made to MAGELLAN'S clouds. (*Outlines of Astronomy*, pp. 614, 615.) In the existing condition of our knowledge, there is no possible positive solution for such hesitations. To clear the field of the uncertainties arising in them, we must advance much farther in our 'Trigonometrical Survey' of the skies, and inspect much more closely the internal structure of the nebulæ: but in the meantime we may abide in the main by a canon which I believe of universal authority—viz., 'The *uniformity* of Nature is more potent than its *variety;*' so that there is ever a degree of safety in continuing by general conclusions drawn from large analogies, provided they are not held dogmatically, or applied to individual instances.

III. But notwithstanding the imperfection of inquiry, there is one difficulty connected with such subjects which ought to be dismissed at once, as having no root whatever in truth or philosophy. Rightly con-

sidered, the gigantic amount of the spaces conceived to divide us from these majestic forms, ought no more to induce a feeling hostile to their reality, than those not dissimilar prejudices of old were entitled to discountenance the theory of a transatlantic continent, or of the planetary character of the earth. Man, indeed, is told emphatically by his Reason—through its disdain of *limits* — that the conditions of his temporal existence ought not to be applied to measure either the possibility of the material framework around him, or the grasp of his own destiny. Nor, though by the acuteness of sense and the culture of the understanding, we go on unceasingly to realize by brighter and grander visions our ideas of Space and Time, can it ever be given us to exhaust either of these august conceptions! Our mightiest Actual must indeed be always but as a point within the Possible; its termination, however remote, only the portal of onward immensities. Observe the position now occupied by the telescope! What are those dim spots, unknown before, which, in numbers increasing with the potency of the instrument, loom on its remotest horizon, unless glimpses to be obtained from its far frontier, of domains it cannot enter—filled also with glories which seem endless? Yes! even the six-feet mirror, after its powers of distinct vision are exhausted, becomes in its turn simply as the child, gazing on those mysterious lights with awful and solemn wonder. I shrink, indeed, before the profundities which

at this moment rise up and are present to my view! Again, reflect on that cloudy speck in ORION; *that* is a starry universe of majesty transcendent, lying at the very verge of what the telescope can see. Well! if any of those faint lights from afar on which the six-feet mirror is now casting its longing eye, resemble in character that spot, the systems from which they come are situate so deep in space, that these rays do not reach our earth until after travelling across intervening abysses during centuries whose number stuns the imagination:—there may be some, regarding which that dim illumination informs us—not of their present existence, but only that they were, and sent forth into space the light we are now receiving, at an epoch farther back into the past than this momentary epoch of our human Race by about THIRTY MILLIONS OF YEARS!

And are such glories ALL? Shrouded from us by the DAY, within which, in the main, man's life runs through its circuit, they would—had day not yielded to night—have lain concealed from us for ever by the light of the sun. The veil is thin, but it would have been impenetrable:—is it not possible, then, that through other conditions of the life to which we belong, and other limitations of our scheme of senses, we are now engirt unconsciously by other universes, real and vast as the world of stars? What mean those dreamlike, inscrutable thoughts, starting up

in moments of stillness, as if from the deeps, like the movements of the leaves during a silent night, prognostic of the breeze that has yet scarce come—unless the rustlings of schemes and orders of existence, near but unseen? But the theme I am touching is only for a master-hand:—

MYSTERIOUS NIGHT! WHILE OUR FIRST PARENT KNEW
THEE FROM REPORT DIVINE, AND HEARD THY NAME,
DID HE NOT TREMBLE FOR THIS GOODLY FRAME,
THIS GLORIOUS CANOPY OF LIGHT AND BLUE?
YET, 'NEATH A CURTAIN OF TRANSLUCENT DEW,
BATHED IN THE RAYS OF THE GREAT SETTING FLAME,
HESPERUS WITH THE HOST OF HEAVEN CAME,
AND ALL CREATION WIDENED IN MAN'S VIEW!
WHO COULD HAVE THOUGHT SUCH DARKNESS LAY CONCEALED
WITHIN THY BEAMS, O SUN! OR WHO COULD FIND,
WHILST FLY, AND LEAF, AND INSECT STOOD REVEAL'D,
THAT TO SUCH COUNTLESS ORBS THOU MAD'ST US BLIND!
WHY DO WE THEN SHUN DEATH WITH ANXIOUS STRIFE?
IF LIGHT CAN THUS DECEIVE, WHY MAY NOT LIFE?

Man o'er-informed with Soul! what seest [illegible]
What dost thou hear?—alas! nor [illegible]
[illegible] the pure vibrations of thy heart
[illegible] dwell [illegible]

PART II.

KEPLER, OR RELATION.

PLATE VII

[illegible] not the stars & mountains? are the waves
Without a spirit?

[illegible] thinks of self when gazing on the sky?

CHAPTER IV.

RELATIONS OF THE SEPARATE ORBS OF OUR GALAXY. THE DOUBLE STARS.—MULTIPLE SYSTEMS.

IT is not possible to reflect long on the wonderful objects that have passed under our review, without the question occurring—What is the internal condition of a galaxy or cluster? Are the orbs composing it motionless? Do they preserve for ever their existing relationship; and, as a consequence of this immobility, are the forms we descry, as they always have been—and alone can be—rigid and changeless? If such inquiries are capable of being pursued with success, it is evident that we shall obtain our first information among the bodies nearest us, I mean among the stars of our own galaxy: and fortunately there is here no longer dubiety or darkness, for we are to follow a course of discovery which might be the distinction of any epoch, and that constitutes one of the proudest titles of ours to be for ever illustrious in astronomy.

I.

There had been observed, at least since the time of GALILEO, a small class of stars, in which individual orbs are found unusually near each other. The more remarkable of these bodies are so close, that they cannot be separated by the naked eye, but appear as single stars, until analyzed and divided by good telescopes. For the most part they are exceedingly beautiful; and some idea of their variety in sizes and relative distances may be obtained from Plate XVIII. where the following eleven are supposed to be seen through the same telescope.

Fig. 1. * CASTOR.
2. γ VIRGINIS.
3. MIZAR.
4. α HERCULIS.
5. α ARIETIS.
6. γ ANDROMEDÆ.
7. RIGEL.
8. γ ARIETIS.
9. POLARIS.
10. STAR IN CANES VENATICI.
11. VEGA.

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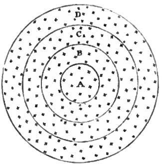
* The figures are supposed to begin at the top of the Plate, and to move from the left hand to the right.

Plate XVIII

DOUBLE STARS

To these singular objects—when however, comparatively few of them were known—Sir WILLIAM HERSCHEL happened to give especial attention, about the close of last century; hoping to resolve, by their means, the problem which proposes to determine the distances of the stars, by noting the amount of their apparent displacement, when viewed from opposite ends of the earth's orbit. At that time the unusual apparent proximity of such bodies was supposed to involve nothing peculiar, but merely to indicate that they lie in almost the *same visual line*, or that their proximity is *optical* only, and not *real:* one star being imagined far behind the other, and divided from it by not less than the wonted interval,—seen, however, in union with it, because the two lie in very nearly the same direction. In his earlier papers HERSCHEL assented to this hypothesis; but when his telescope revealed to him that such stars exceed in number every previous anticipation, he discerned its fallacy, and foreboded a significancy in them far more profound, which he afterwards evolved by a process of ratiocinative observation of the most pregnant kind, and which is still one of our most brilliant examples of philosophic inquiry into the remote unknown.—Let us notice, in the first place, his reasons for believing that the *frequency* of the occurrence of such objects must indicate some *physical peculiarity*—some new fact in the higher astronomy.

I. The argument which chiefly weighed with him may be familiarly illustrated as follows. Suppose a number of peas thrown at random on a chess-board, what would you expect? Certainly, that they should be found occupying irregular or random positions: and if, contrary to this, they were, in far more than average numbers, arranged by *twos* on each square, it would be a most natural inference that here there is *no* RANDOM *scattering;* for the excessive prevalence of the binary arrangement would indicate forethought, design, *system.* This inference is so direct and urgent, that we unhesitatingly act on similar considerations in the conduct of life: and its applicability to stellar phenomena will be at once apparent. Again, employing the diagram formerly made use of, where the central region A is supposed



to contain stars of the first magnitude, the ring B those of the second, &c.; is it not clear that on the hypothesis of

the stars in these spheres being uniformly scattered, one might easily calculate—say, *how often* a star of the third magnitude would appear so closely behind a star of the first, that the two must seem, to the naked eye, almost to coalesce, and thus to form a double star? The question as to the probable frequency of such coalitions is manifestly a mathematical one, and resolvable by a strict process. If, then, we find no more than what that process would incline us to expect, we shall be led to no further conjecture regarding the stellar systems; but if, on the contrary, that number is far exceeded by the reality, we must be startled by the presence of a phenomenon not to be explained by the circumstance of one star lying closely behind the other; for the excess of this number over the calculated optical coalitions, compels us to infer a new law—some ARRANGEMENT among classes of stars, distinguished in all likelihood by characters formerly unknown, and of which this unexpected proximity is the external index.

Passing, however, from this brief general explanation, and to render the argument thoroughly palpable, as well as to show the probable extent of the field to which the discovery thus opening must introduce us, I shall produce a few tables from the great work by STRUVE. They represent the actual numbers of stars found in close proximity, and contrast them with the very few which

calculation shows us might be expected, if the conjunctions were optical only.

Let me premise two explanatory remarks. 1. It is necessary to attain some notion, more or less distinct, of the size or value of the *quantities* of which I am to speak. If the whole circuit of the heavens were divided into 360 equal parts, each of these parts would be termed a *degree*. If one of these degrees were subdivided into 60 equal parts, each of these parts would be what is termed a *minute;* and if a minute were again subdivided into 60 equal parts, each of these very small parts would be a *second*. Now, the distances we have to deal with are expressed in seconds, and they are so small that it will cost my reader no little difficulty to apprehend their real or comparative sizes. One fact may assist him. The diameter or breadth of the sun is nearly 2000 seconds, so that if we suppose that breadth, as it appears to the eye, to be divided into 2000 equal parts, one of these parts will be about the size of one second.—2. For the sake of convenience, the approximate or conjoint stars are divided into *orders*, determined by the distance of their constituents. The first eight orders include all bodies within 32 seconds of each other, *i.e.* not separated from each other by so much as the apparent breadth or diameter of the planet Jupiter. These are essentially double stars, *i. e.* they appear single to the naked eye, nor can the nearest of them be separated

without the aid of the finest telescope that art has yet produced.—The subsequent tables will now, I hope, be understood without difficulty. The one first presented, contains all the double stars from the Pole to 15° south of the Equator, in which neither constituent is very much less than the least we can discern with the naked eye; they should be easily seen, at all events, with a good common telescope. From the care bestowed in the survey, this list must include nearly the whole of such objects in these regions of the heavens.

TABLE I.

Orders.	Distances.	Numbers probably only optically within that distance.	Numbers observed.	Difference of the two former Cols. showing the No. of really approximate stars.
I.	0″ to 1″	.05	62	62
II.	1 to 2	.14	116	116
III.	2 to 4	.56	133	132
IV.	4 to 8	2.24	170	128
V.	8 to 12	3.73	54	50
VI.	12 to 16	5.23	52	47
VII.	16 to 24	14.94	54	39
VIII.	24 to 32	20.91	52	31
Sums,		48	653	605

How emphatically our table intimates that these double stars are, as Herschel so soon suspected, peculiar and most interesting phenomena! So far from the

principle that they are only *optically* double—*i. e.*, that they appear near, because of the sameness of the directions in which they lie—so far from that principle being able to explain the whole existing arrangements, it accounts, as the table shows, for the proximity of no more than 48 sets out of 653—leaving 605 to be explained by some other law, and to stand forth—as they impressively did to the mind of our philosophic astronomer—the indices of unknown and profound design! The next table refers to stars whose small companions are of much less magnitude, and is not so *complete* a list. The distances corresponding with the orders are the same as above.

TABLE II.

Orders.	Numbers optically double.	Numbers observed.	Numbers really double.
I.	1	16	15
II.	3	82	79
III.	11	176	165
IV.	43	214	171
V.	71	124	36
Sums,	129	612	483

In other words, of 612 conjunctions among the smaller and more numerous stars, there are 483 un-

accounted for by the notion that the proximity, only indicates that one star is far behind another. STRUVE, in the introduction to the Catalogue referred to, has pursued the inquiry to its apparent limits—*i. e.*, until he reaches the distance at which the probability of the *conjunction being solely optical*, undoubtedly prevails. The following table, containing complete lists of the *brighter* stars only, gives his conclusions.

Orders.	Distances.	Numbers probably optically related.	Numbers observed.	Numbers physically related.
IX.	32″ to 60″	1.536	15	13
X.	60 to 120	6.439	15	9
XI.	120 to 300	7.74	17	9
XII.	300 to 600	27.56	38	10
XIII.	600 to 900	21.50	25	3.5
Sums,		65	110	44

It cannot fail to be noticed, that the number of stars optically related is here much *larger* than in the former table; and in Order XIII. nearly the whole are related optically; thus evincing that the limit 15′ or 900″ approaches to the usual or average interval of celestial space between independent stars of those magnitudes. The result of the whole may be briefly stated:—*In reference to stars not smaller than the least we see with the naked eye, there is a possibility of the existence of a certain*

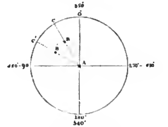
unexplained connexion or relationship wherever the distance is within 15′, *or about half the diameter or breadth of the Sun; when the distance is less than* 5′, *or one-sixth of the breadth of the Sun, the probability of such a connexion is very considerable; and in almost every instance, whether the stars be large or small, where the distance is less than* 30″, *that connexion may be predicated with an approach to certainty as near as can be attained on subjects so speculative.* The word *speculative*, as employed above, must not be supposed of the same meaning as *fanciful;* for the foregoing conclusions are as sound and warranted as if they rested on a long induction of actual and known connexions. The character of the specific connexion we may not, on any grounds I have yet unfolded, venture to assign; but, that a connexion exists, far spreading and memorable, constituting an important feature among the complex arrangements of our galaxy—is sustained by that maxim, which is at the root of all philosophy, that Nature is not capricious, and that analogies or correspondences steadfastly indicate some Law, real though unrevealed. It is from the confidence with which he rests on this belief,—one inseparable from his being,—that the true philosopher derives his powers as a seer. The analogy or group of collocated events is the bud of mighty truth, whose growth or fulness he descries from afar, and proclaims in words of prophecy its approaching advent.

II. The force of considerations like the foregoing was not lost upon HERSCHEL. Of all men—with perhaps one exception—who ever adventured into unknown regions of the heavens, this great Inquirer was most deeply penetrated with an enduring conviction of the all-prevalence of Law, whose characters were first indicated by "collocations;" and he evinced a marvellous quickness and solidity in interpreting the remotest hints; a feature—a single line was enough, and he divined the outline of the portrait. Rising, in the present instance, to the utmost height of justifiable speculation, he proceeded to the next step in the bold induction—viz., to the question as to the *nature of the bond or union* between these singular bodies; inquiring whether *gravity*, a law already known, would not account for the connexion which seemed established, and whether, in such a case, the suns would not—like our planets about their central luminary—*revolve around each other* in definite orbits? HERSCHEL, however, was too sound a philosopher to be withdrawn, even by the fascinations of so brilliant a conjecture, from that laborious path which alone can guide to truth; and at the same moment at which he threw out his ideas, he urged astronomers to confirm or disprove them by observation, exhibiting labours of his own by which, if extended and repeated after long intervals, all mystery would be withdrawn from these singular bodies. Nor did he summon

unwilling labourers. I can compare the sensation occasioned in the astronomical world by these bold views only to the excitement diffused through Europe when Columbus discovered in the far West new and mighty Continents resting amid the formerly void and mysterious ocean. To follow up HERSCHEL's examinations, has constituted the chief ambition of observers from that time until now. Observatories, with gorgeous appliances, have been carefully suited to that specific purpose; and many private observers have, with their utmost means, toiled in the same walk. Before the close of his earthly honours, the veteran had himself accomplished the measurements—that is, had fixed the places of above 500 double stars. In 1824, Sir JAMES SOUTH and Sir JOHN HERSCHEL produced a catalogue of 380 stars, whose distances and angles of position they had jointly fixed with admirable precision. SOUTH followed it up by a distinct catalogue of 480; and HERSCHEL, now also observing apart, completed a list of upwards of 3300 of such determinations. Inferior to none, however, was M. STRUVE, of Pultova, who, aided by that noble instrument, the Dorpat Equatorial of FRAUENHOFER, first analyzed and afterwards measured the positions of nearly 3000 double stars, with a precision that cannot be surpassed. These catalogues, however, do not reach farther than 15° south of the Equator; but this has now also been explored, and another fruit of the

memorable expedition, to which I have already alluded, is the discovery there of upwards of 2000 more of these objects. Nothing was known, previous to Sir JOHN HERSCHEL'S voyage to the Cape, concerning the double systems of that vast celestial space, except through an observatory at Paramatta, founded by Sir THOMAS MAKDOUGAL BRISBANE, through whose munificence British science thus became co-extensive with British dominion. Gracefully does the laurel due to such actions adorn the green autumn of life!

The *mode* by which astronomers examine and record the relative positions of stars presumed to be connected, so that they may be compared with distant records made at other epochs, is extremely simple. Suppose that a circle with cross diameters, such as the following, were



placed in the eye-piece of a telescope—that is, *so* placed, that both it and the stars should be visible at one and the same time. Suppose also that its circumference were divided into 360 equal parts, viz., degrees, begin-

ning at 0°, and passing through 90°, 180°, 270°, to 360° or 0° again, and let the reckoning proceed without interruption to 450°, 540°, 630°, &c. &c. Now, if one of the associated stars be brought to the centre A of the cross lines, the other will lie somewhere else. Suppose it to be at B, and draw a line through A and B to meet the circle in C; this line will cut off a part of the circle between 0° and C, containing a certain definite number of the equal parts now spoken of: and if that number be known, the exact distance of the point C from 0° may be laid down in a chart or figure. If B should now change its place relatively to A, and, after a given length of time, occupy the place B', this change must be immediately detected by the observer; for he would find that the line AC'' through A and B' now cut off a greater number of those equal parts, or a larger part, $0°C''$, of the circle than formerly. And thus, by noticing carefully the number of degrees, or of equal parts of the circle cut off at all times by the line through the centres of the two stars, their changes of position—if such there were—might be clearly ascertained. The distances of the stars—that is, the lines AB, AB'—might also be carefully measured, and their variations recorded. To effect such measurements, requires the finest instruments; but Art is now fully equal to the task of producing them: the error of the instrument being very rarely so great, as the error of the observer in using it.

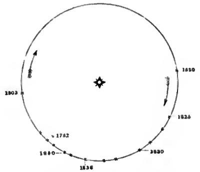
To impress this process of observing more clearly on the memory, and also to *represent* the result, so that it cannot be mistaken, I shall take one example. The star ξ Ursæ, a double star in a hind foot of the Great Bear, is one of those which have been observed longest and most assiduously. The following table, extracted from an extensive record, gives the relative positions and distances of its individuals, at the various epochs named, as well as the observers by whom the quantities were determined:—

POSITIONS AND DISTANCES OF THE STARS OF ξ URSÆ.

Year.	Position.	Distances.	Observers.
1781–97	143° 47′	....	Herschel, Sir W.
1802–09	97 31	....	do.
1820–13	276 21	....	Struve.
1825–22	242 32	....	South.
1826–20	238 —	1″.68	Struve.
1828–23	220 48	1 .89	do.
1830–27	211 48	1 .56	do.
1832–28	193 36	1 .68	do.
1834–43	184 36	1 .85	do.
1836–44	171 12	1 .96	do.
1838–40	159 42	2 .36	do.
1840–41	156 42	2 .20	O. Struve.
1842–34	146 30	2 .43	Maedler.
1844–40	141 27	2 .65	do.
1846–41	133 24	2 .5	do.

The recorded *distances* of the two stars vary in a manner apparently ambiguous, if not contradictory; which may be referred partly to errors of observation—so small and evanescent are the quantities; but the most cursory glance at the angles of *position* detects through all the period in the table, a regular change of relationship in this respect—the stars having returned in 1843 to the direction in which they were found—one from the other—in 1781. That these numbers, however, may speak to the *eye*, I shall represent them by a diagram;—assuming, in the meantime, that one of the stars is stationary in the centre of a circle, as below; the points

ξ Ursæ



on the circumference of the circle, marking the place of the other, at the several periods. Can the significance of this remarkable motion be now mistaken? With an evidence which admits of no increase, it is established

by these numbers, that the one star has—since observation began on it—effected more than a revolution around the other; and although in some places it seems to have moved by starts or with great rapidity, while in others its course has been slow, shall we hesitate to recognise the eminent fulfilment of HERSCHEL'S prophecy—viz. that a grand orbital motion belongs to this double star? Had I traced the footsteps of others of these orbs—the fine star CASTOR, or the singular pair of γ VIRGINIS—the issue would have appeared the same: so that, however extraordinary, the *fact* cannot be questioned.—We are thus in presence of a phenomenon never imagined in any prior age—schemes, viz. of majestic suns rolling around each other. And yet how soon are the most wonderful truths taken hold of, and reduced to common-place! Though separated from the epoch of this discovery by only a brief half century, we wander now through those fields of stupendous activity, as if the domain were but one of sun and planets—opaque inferior globes receiving warmth and light from a luminary they attend. Revert, however, to the moment when—such things all fresh and new—that great philosophic mind, armed with a fitting eye, bared itself beneath the heavens—open to their darkest mysteries. Silence—the wondrous silence of midnight, then pervaded all the regions of stars;—only some dim collocations hinted of ordinances to which their orbs might be subject, and of august evolutions. Shall I

venture to speak of the meditations of our great Observer then; or rather—passing this as an unfitting intrusion—am I not permitted to refer to a feature of the scene, which surrounds its grandeurs with our sympathies, and in so far makes it of earth, by connecting it with not incongruous human emotions? During these watchings, HERSCHEL was never alone: amid his loftiest speculations he had a cherished companionship. Sharer in his toils, while actively co-operating towards his triumphs, was a devoted maiden Sister:—She it was, in the words of the best of authorities, who took down notes of the observations as they issued from her brother's lips; who prepared the rough copy ere the dawn of day; who, with unceasing perseverance, reduced every entry of the night, made every calculation, and kept everything in systematic order: she it was—also gathering ever and anon, spoils which were peculiarly her own—Miss CAROLINE HERSCHEL, who sustained our astronomer while working out his imperishable fame! This venerable lady, who after Sir WILLIAM's death withdrew to her native Hanover, was in one respect most fortunate; for her years were stretched out until she saw the culmination of her brother's glory. Prior to her demise, hope had long become certainty, and prophecy passed into truth; and assemblies of the Learned, through means of just though unusual tributes to herself, had recognised the immortality of the Name she bore!

II.

The systematic character of the binary stars, as well as the mode and progress of the discovery, having been made known to my reader, I shall proceed to unfold what is of chiefest interest in the nature of their orbital motions. But, in the first place, with reference to the numbers of these systems, let me state it as now amply borne out by experience, that the existence of a double star whose constituent orbs are within the limit of distance indicated by M. Struve, constitutes of itself a sufficient probability that we are in presence of a revolving system. These singular arrangements, indeed, throng the skies; and although a considerable series of years is required to reveal details as to the larger systems, we can already speak definitely of the general structure of more than a hundred of them,—a number amply sufficing to elucidate their leading characteristics.

I. The periods occupied by these motions of sun around sun are exceedingly various—ascending from a brief and rapid cycle of fifteen or sixteen years to others occupying thousands; nay, some of the changes are so slow that they are next to imperceptible—betokening circuits of immense spaciousness and duration. With regard to the *same pair* of stars, the period of revolution must be the less the nearer the bodies are to each other,

—just as the remoter planets of our solar system have the longer courses; but as *two separate pairs* will vary in this respect with their *size* or *weight*—a lighter pair at a definite distance consuming a longer time than a weightier, in completing its cycle—we cannot expect to connect rigorously the times of revolution with the apparent intervals between the orbs. Nevertheless, our hypothesis of an "average magnitude of the stars" does us again good service. Binary systems of the swiftest revolutions, are without exception also the closest; from which we may safely infer, that in such cases, apparent proximity indicates real proximity; and also that swift systems must of all others be rarest in our catalogue, inasmuch as objects of that character, if very remote, may never be recognised as binary, or *separated* even by our most effective telescopes.—In proceeding to speak of the definite periods of the double stars, it is necessary to divide them into two classes. Of the periods of systems of the first class we are tolerably certain, either because entire revolutions have been noted, or because enough is known as to the *exact path* followed by the star, to entitle us to estimate the variations to which its velocity is subjected. How essential is this latter knowledge, even to an approximate conjecture concerning the habitudes of any binary system, is amply illustrated by the diagram in page 145, representing the successive positions of the stars of ξ Ursæ Majoris. Were one to

calculate the orbit and period of that star on the supposition that it has an uniform velocity—taking as our guide in one case its velocity between 1802 and 1825, and in the other that between 1781 and 1802, how inconsistent the results, and how erroneous either!—This first class is far from numerous; nor are the best statements I can give inaccessible to objection. For the most part, I have adopted the most recent elements of M. MÄDLER of Dorpat.

Stars.	*Periods of Revolution.*
ζ HERCULIS	30.22
η CORONÆ	42.5
ζ CANCRI	58.27
ξ URSÆ MAJORIS	61.5
τ OPHIUCHI	87.04
λ OPHIUCHI	89.01
ξ LIBRÆ	105.5
ω LEONIS	117.6
3062 Σ	146.83
μ BOOTIS	146.67
γ VIRGINIS	169.44
α CENTAURI	290.—
δ CORONÆ	478.04
CASTOR	519.77

It is difficult to imagine the significance of these

great cycles, in their bearing on the internal condition and economy of the orbs partaking of them. In one respect, they may correspond with the yearly course of our world; for as the paths through which the stars move are not *circles*, but *ellipses*, they must pass through various degrees of proximity to each other, and therefore undergo varying mutual influences.—The second class of double stars cannot yet be ranked with objects concerning which we have exact knowledge. Generally speaking, we have followed them through only a small part of their courses; and the *shapes* of their orbits are undetermined. Motion, indeed, has everywhere been detected; and also its velocity during a short period; but — referring again for illustration to the case of ξ URSÆ MAJORIS—that period may have been not the epoch of the *mean* velocity, but of its *quickest* or *slowest* rate. The time of revolution computed from it, therefore, can be no more than a rough approximation, differing in all probability in the case of the larger cycles, by some centuries from the true one. But amid all this uncertainty, with what care are these objects now watched, and the results discussed! No practical science has advanced so rapidly as the science of observation; nor of that can there be a more signal illustration than a comparison of the recent records of DORPAT, POULKOVA, and KONIGSBERG, in reference to the double stars, with those earlier catalogues, which simply revealed their orbital

character! No slight in this to the older astronomers; but rather the source of abundant hope, and confidence increased in our deductions, though they may not rest on the experience of so long a time.

Stars.	*Periods of Revolution.*
210 Herculis	132
ξ Bootis	435
49 Cephi	466
ε Hydræ	584
ι Leonis	561
42 Ceti	696
ι Cassiopeiæ—1 pair	1065
" 2 pair	2785
γ Leonis	1342
γ Ceti	1478
α Piscium	2928
ζ Coronæ	3542
ψ Cassiopeiæ	5468
Polaris	6069
ζ Ursæ Majoris	7659
γ Andromedæ	10376

I have selected the foregoing stars from Mädler's extensive list, either because the individual object has been noticed for a period comparatively prolonged, or appeared recommended by some other peculiarity carry-

ing with it a presumption of *weight*. The following is MÄDLER's synoptic view of what he considers established within certain limits of accuracy:—

Nos. of Stars.				*Periods.*
30	from	100	to	500 years.
80	„	500	„	1000 „
162	„	1000	„	2000 „
50	„	2000	„	3000 „
33	„	3000	„	4000 „
16	„	4000	„	5000 „
27	„	above	„	5000 „

There is another principle of much importance, which enables us to *select* among objects whose distance is considerable, and where the chances are therefore increasing, that the proximity may be apparent or optical only. A great many stars have what are termed *proper motions in space*—*i. e.*, they seem slowly shifting their places in the sky, moving regularly onwards by small annual quantities, in what appear as yet straight lines, but which doubtless are portions of vast curves. Now it happens that amid a great variety of motions, *both* the constituents of a number of stars which are optically connected, partake *equally* of this proper

motion; that is, the one star moves annually in the same direction as the other, and by precisely the same quantity:—how inappreciable the probability that they would do this, were they *only* optically connected? Stars *may* exist indeed, separated by gulfs of space, which have proper motions that would appear the same when viewed from the earth; but assuredly the chance is trifling that pairs of such objects would frequently lie nearly along the same line! We hazard, therefore, little in asserting that the objects in question are *connected physically;* this union being the cause of the identity of their proper motions: so that although because of their considerable distances they might have seemed ambiguous, all doubt as to their nature is removed. Among such systems I distinguish the following:—

Stars.	*Distances of Constituents.*
CASTOR, and a Third Small Star	72 seconds.
40 ERIDANI	84 "
REGULUS	180 "
ϵ and 5 LYRÆ	210 "
θ^2 and θ^1 TAURI	336 "
36 OPHIUCHI, and 30 SCORPII	720 "
MIZAR and ALCOR	720 "

Between these last two stars, MIZAR and ALCOR, (ζ Ursæ Majoris,) a small star of the eighth magnitude is interjacent, which does not partake of their proper motion. How stupendous the energies in systems constructed on so vast a scale; and considering the sluggish motion of our own NEPTUNE, whose remoteness from the sun is not comparable to intervals like these, what wonder that in performing their revolutions they consume many centuries! In respect of their magnitude then, no uncertainty should attach even to the largest of these computations by M. MÄDLER: nay, if some of the pairs whose orbits are well known to us, had been separated by apparent distances like the foregoing, periods of revolution must have belonged to them, surpassing his most extensive statements. Taking *P* OPHIUCHI as our standard, whose period seems about eighty years and the distance of its stars, 4″.33,—we deduce from a sure dynamic theorem, that if that distance had equalled the one of 40 ERIDANI, the period of revolution must have exceeded 7000 years; and if the orbs had been as far apart as MIZAR from ALCOR, that they could not have completed their circuit in much less than 2000 of our world's centuries! But why estimate the ongoings of these majestic works by the units of our little earth? To reckon up the days and months of human life, the duration of royal houses, the periods of empire, such units serve well; for these are things on which the sun

shines not often,—the grass withers, and they are gone: to measure the surface-changes even of our globe, the entire sum of man's existence has been found inadequate; —how then carry up its units to the skies, and attempt to read, by their tiny aid, those celestial annals which must be divided according to numbers of their own!

II. We now approach the question as to the interior significance of these schemes of double stars. The diagram representing the course of ξ URSÆ is so emphatic in this respect, that I must again refer to it here.—(Page 148.) Observe well the velocities of the point apparently in motion, how they change as it passes around the circumference of that circle. It is clear, I think, even on inspection, that *law* of some sort prevails over these variations: the star does not start from a quick motion to a slow one, or *vice versâ*, but runs through a definite course. What, then, is its law? A question which long ago, with regard to the motions of the planet MARS, pressed on the intellect of the immortal KEPLER; and in his very language it has again to be answered now. Once more, indeed, we stand with KEPLER and the great NEWTON, on the elevation below which the material universe, in its everlasting order, lies fresh and youthful for ever: again the truth is borne to us, as if for the first time, 'the revolution of a planet is only the repetition of the fall of a stone.' Most strange revelation!

In the path of a stone whirled through the air, the graceful curve of a jet of water, or the course of a drop of spray, *there*—in the energy through which a sparrow falls—is the power obeyed by these great stars! It is not HARMONY alone—*that* without which the external world would be to us no other than a fantastic dream, but UNITY also,—the eternal and unchangeable WORD, unfolding itself in expression wondrous and ever varied, but the *same* through all things.—There are two classes of considerations which here require our attention.

1. What are termed, in reference to our planetary system, the *laws of* KEPLER. The only two of them which have any relation to the case, are rigorously true amid the binary stars. Wherever an orbit has been thoroughly analyzed, a thorough consistency is found with the following facts. *First:* The one star seems to move around the other, not in a circle, but an *ellipse*, the second star being in the *focus*, and not the centre of the ellipse: and, *secondly:* The velocity of the revolving star regularly increases with its proximity to the other. These two principles are in themselves somewhat technical, and I have therefore transferred a full exposition of them to a *note;** but it will be easily

* The LAWS OF KEPLER are now so generally and accurately understood, that I did not consider it necessary to explain them fully in the text. But as it is impossible to appreciate the validity of our conclu-

seen that they comprehend a large range of variations alike as to the distances and relative positions of the two orbs. Nay, they define these variations so unerringly, that in several cases we can now prediet, for coming years, the aspects of such systems. Notwithstanding this remarkable eircumstance, however, we should judge erroneously, in expeeting among the double stars only a recurrence of phenomena with whieh, in our solar system, we are now familiar. On the contrary, there are essential differenees;—*two*, in reference to the general eharacter of the motions. *First:* One memorable and evidently fundamental arrangement in our system finds amid these loftier

sions respecting the systems of the douhle stars, should any misapprehension exist concerning the discoveries of this illustrious man, I have thought it right to state in this manner distinctly what they were.

The benefit conferred on astronomy hy COPERNICUS was confined to his estahlishing the fact that the earth is a planet, instead of being the fixed centre of the universe; from which he inferred the general character of the solar system—viz., that it consists of a grand central luminary, around which a numher of small opaque hodies or planets revolve. Bnt the qnestions remained—In *what paths* do these planets move—what their exact conrses? Do they retain the same velocities at all parts of their orbits? and if not, according to *what law* does the velocity of each vary? Also, is the solar system made up merely of a number of *individual* hodies rolling around the snn? or has it any great principle of *unity?* These are the difficulties which KEPLER overcame.

1. He discovered—chiefly throngh aid of TYCHO BRAHE's gigantic labours on the planet MARS—that the curves in question are not *circles*, as had been previously supposed, but *ellipses*—the sun occupying, not

schemes no trace of resemblance or counterpart: I allude to that singular law which has ordained that all planetary motion, whether of revolution or rotation, and (with one exception) whether of primary or secondary orbs, take place *in the same direction*. From west to east is the order of every movement which forms part of our planetary mechanism; but among the double stars there is no restraint, or appearance of it,—as many

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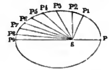
the centre of the ellipse, bnt the *focus*,—a point which is farther removed from the centre, as the ellipse is more oblong. The subjoined figure is a representation of such a curve when the position of the sun is *S*.— In the planetary system no ellipse greatly differs from a circle, so that the sun is never far from the centre of the orbit; but in every case the LAW, as I have stated it, accurately obtains.

2. Instructed in this case likewise, by the records of TYCHO BRAHE, KEPLER next discovered that every planet *moves quickest when nearest the sun;* and the law of the variation of the velocity will be understood by aid of the subjoined diagram. Suppose *S* the sun, and the planet at



P, P^1, P^2, P^3, &c. &c., at the end of successive months, or any other fixed period. The line *S P*, *S* P^1, &c. has a technical name, which should be known,—it is termed the *radius vector*. Now, take the first month, during which the planet has moved from *P* to P^1: the *radius vector*, it will be seen, has in this time *swept* or passed over a pretty broad triangular space, *P S* P^1. Take again any future month,—the one, for instance, during which the planet has moved from P^4 *to* P^5,— the *radius vector* has there swept over the long and narrow triangular space P^4 *S* P^5. Now, the law is this—the space *P S* P^1 of the first

systems moving in one direction as in its opposite: a fact barren at present, probably, but assuredly not without significance. *Secondly:* While the orbits of all the planets and satellites are *almost circular*, or ellipses of very small elongation, the curves of the double stars, although always ellipses, have every degree of eccentricity — in this case also refusing restraint, and having almost the freedom of the

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case is precisely equal to the space $P^4 \ S \ P^5$ of the second: and universally, *the radius vector sweeps over equal spaces in equal times.*

The immortal NEWTON—whose place in scientific history succeeds that of KEPLER—drew an inference of the highest import from these two laws. Treating them by means of a peculiar species of analysis invented by himself, he was enabled to conclude, that in every system in which two orbs are connected in the manner described by these laws, the grand force of gravity prevails and controls their union; nay, the law of gravitation is nothing other than a compression of KEPLER's *two* principles into *one.* Now, let my reader carefully observe the following fact:—in every binary system in the heavens which has been sufficiently examined, the two suns are found *to obey unswervingly* KEPLER's *two laws*,—from which, precisely by NEWTON's process, we infer that these grand orbs are also held together by the FORCE OF GRAVITY.

3. KEPLER's third and last achievement established the *unity* of our solar system, by tracing among the orbits and motions of the *different* planets a principle of connexion; but as, on several important accounts, we are not yet in a condition to apply this law in an easy or readily intelligible manner to the phenomena of the double stars, I shall refer to it no farther now, than to state, that to it we owe the power of deducing such periods as I have attributed to MIZAR and ALCOR, &c., and also the *masses* of a few systems—as will be seen farther on. The student, slightly versed in such contemplations, will comprehend this mere allusion without difficulty.

comets. For instance, the ellipses below represent the probable orbits of γ Virginis and α Centauri—

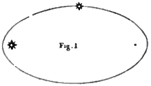


Fig. 1

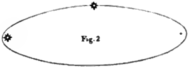


Fig. 2

both very elongated; while in Castor, or τ Ophiuchi, there is little difference from a circle. It is not difficult to discern in such figures, especially in the ellipse of α Centauri, how liable to mistake must be our conclusions from brief periods of observation in cases so remarkably delicate; owing to the contrast of the velocities of such bodies at the periods of their greatest proximity and greatest elongation. If, too—as it is allowable to suppose—each of these suns is attended by planets, how extraordinary the physical condition of these planets, and how inextricable their mechanical relations! Besides passing through the varying climates of a year depending on its revolution

around its own luminary, every planet of either system must undergo the changes of another cycle, whose course is the great period of the Binary System, and which at one of its terms must subject it to the influences of two suns virtually in contact! And as to the movements of bodies acted on by forces so strange and fluctuating, —why, within this most regular system of ours, whose plan and entire dispositions are the simplest that can be conceived, it has tasked all our powers of computation to follow out the smaller irregularities of a Moon; and the detection of a foreign disturbing cause unknown before, has recently surrounded some names with a most just and enduring glory,—shall we dare, then, to raise our thoughts toward schemes of whose order we can have little other idea except that it is an order of *successive bouleversemens*—the virtual periodic overthrowing by each sun of the independence of the system established by the other, which again is in so far to recover itself, during the years leading to their elongation? We boast of our mathematical analysis; and assuredly its arts are most subtle; but it fails alike in power and comprehensiveness; nor can it look to those higher problems without being struck with helplessness, and averting its face in despair.

2. Rising now to contemplation of the energy sus-

taining the mechanism of the Binary Systems, we again meet with the law or force of Gravity—that great power through which the harmony of all planetary motions has been found to flow; but in this case it acts in a form somewhat modified, and perhaps better calculated to prepare us for understanding the grander mechanism of the universe.—The constitution of our solar system is peculiar. The central orb is so immense compared with the planets surrounding him, that his action is almost the sole effective one in the system; and the planets, for most practical purposes, may be regarded simply as points prevented from falling towards him by their own velocities (which, as with a stone in a sling, tend to make them fly off into space). We are accustomed, therefore, to think of systems as necessarily composed of a preponderating body and dependents; and even until quite lately, when astronomers spoke of the possibility of an universal mechanism, their conception uniformly was of a scheme of countless subservient orbs revolving around some enormous, perhaps invisible mass, — worthy, because of other attributes, to be the centre of the material creation. But with the Binary Systems we have quite another arrangement—one, too, which we are apt to misrepresent through our usual mode of speech. The phenomenon is not in reality that of one star revolving around another and subordinate to it, but of orbs

wholly or nearly co-equal, *united in a common motion.* We cannot ascertain by observation the relative positions of two bodies so related, unless by supposing one of them *fixed*, and referring the other to that as a fixed point; and this representation fortunately serves every theoretical as well as practical purpose; but the fact is, *both stars are moving in orbits around their common centre of gravity, which alone is a fixed point in the system.* If the companions were equal in magnitude, the centre of gravity would be the middle point of their distance; and, generally speaking, it is nearer the larger one in proportion to its mass: around such a point, however, the masses and motions of the system are ever balanced. And, similarly, could we suppose three or four, or any number of orbs associated in a common scheme or mechanism, there is no need of a grand central controlling orb, acting as a sun on planets, but only that the whole be adjusted so that their centre of gravity is the fixed point around which the various motions proceed. How easy, then, to imagine a grand system inclusive of all the stars: nay, those remote nebulæ may also be thus balanced, and by their mighty evolutions constitute the highest point of a vast ascending scheme! Neither is it so hard as in the planetary system, to rid the mind, under this view, of the prevalent conception, that the attraction of which we speak is an *external force* impelling certain bodies towards another.

There is no such power. On the contrary, it is something inherent in each particle of matter: and its ultimate form in any system, is the mere sum of the tendencies of all the particles composing that system:—the centre of gravity and motion, being the mere point where these opposite tendencies find their balance—the system's *null* point. As to this tendency itself—whose results are so amazing—which stretches its voice through the remotest heavens, and sustains their mechanisms—what is it? Whence its origin? Where else shall we light upon its footsteps? Farther at present we cannot discern, than that it is part of the life of matter as we behold it; but adequate to bind every particle—nay, the minutest atom on the sea shore—with all else that exists. If our conceptions are not erroneous, the rotting leaf cannot change its form and position; not an atom of it can pass from one point of space to another, without telling, even to the remotest star, the alteration of its character and elements, and begetting in so far as it is concerned, new movements in the evolution of the Universe.

III.

Before passing to the higher contemplations to which the foregoing thoughts emphatically summon us, I must

remark on some very interesting details connected with the double stars. I shall confine myself to three.

I. To one double star, 61 Cygni, a memorable history belongs. It is that star which in the hands of the illustrious Bessel first revealed the unlooked-for fact that the remotenesses of these wonderful bodies are now measurable by our instruments. After an investigation, undertaken expressly for this purpose, and carried out with a skill and perseverance which must render it ever classic in astronomy, Bessel detected that 61 Cygni has a *parallax*—that is, looking from the opposite ends of the earth's orbit, we can see it in slightly different positions. But this change of position—although very small, only about *one-third of a second*—enables us to state how far off the star is, compared with our distance from the sun; and we find its remoteness 657,700 times that large quantity. This is one of those numbers which we must measure by our new unit: it represents a space through which light would scarce travel in *ten years!* Bessel himself appears to have rejoiced in this discovery, *chiefly* because of the proof it gave of the rapid advance of the science of observation, which seemed hastening to a period when we shall discourse with certainty concerning quantities much smaller even than the parallax of 61 Cygni. And his hopes are in course of swift fulfilment; for no doubt can exist that the unpa-

ralleled machinery of Poulkova will yearly evolve results in this direction, which a very brief period ago would have been deemed impossible. Already we have obtained the following parallaxes from that great observatory:—

61 Cygni . . .	0″.349	Struve.
	0.348	Bessel.
1830 Groombridge	0.226	Peters at Poulkova.
α Lyræ . . .	0.207	Do.
ι Ursæ Majoris	0.133	Do.
Arcturus . . .	0.127	Do.
Polaris . . .	0.067	Do.
Capella . . .	0.046	Do

To give these figures their true significance—take the case of Polaris: it seems removed from us by no less than 3,288,500 times our distance from the sun; an interval which could not be overpassed by the swiftness of light in less than *fifty* years; and yet we have accurately measured that interval—the surveyor has borne his line across it, and fixed it at the other extremity. Thinking of such achievements—not, indeed, of the mere fabrics of brass we term our instruments, but of the intellect which has constructed and can employ them —well may we indulge in high hopes for future inquiry! It is the contemplation of triumphs like these which convinces us that there can be no term or limit for Man-

The country through which we travel is in truth a vast upland thronged with mighty mountains, one range seeming the last only until it has been ascended: nay, and those mists which rest on the far horizon are a concealment only, and no termination; for ever and anon, as the ages course, that white cloud parts like the unfolding of a royal gate, and lo! through the opening some noble peak, hitherto unseen by human eye—its top burning in the Sun!

But to return to 61 Cygni, which has yet another interest. This star, as I have said, is *binary*, and its approximate period is 500 years. Now, the apparent distance of the two orbs from each other is 15″; and—this space converted into actual miles by aid of the known parallax—we deduce the mean distance of the bodies to be about forty-four times our distance from the sun. But, the planet Neptune—the remotest yet known in our planetary system—is only thirty times farther off than we are; so that the two suns of 61 Cygni constitute a system, between whose chief orbs there is an interval greater, by one and a half times, than that which separates Neptune from its centre of motion. Still farther, the period being known and the distance, we can infer by an easy process the amount of the *attractive power* necessary to uphold such a system—in other words, the *actual mass* of the combined orb; which appears about

one-third of the mass of our sun. On the basis of these elements, something of a definite conception may be formed regarding this interesting system.

II. There is another double star, α CENTAURI, a noble orb in the Southern heavens, whose history, also, will be ever remarkable. The parallax of this star, though not made known until after BESSEL's labour on 61 CYGNI, was really ascertained prior to the conclusion of the labours of the great German, by a man of no dissimilar habits of mind, over whose loss science had likewise recently to grieve—I mean my lamented countryman, THOMAS HENDERSON. Unquestionably the glory of first marking down a fixed distance among these external spaces belongs to this latter astronomer; with regard to whom it may be permitted us to deplore that, unlike the case of his German compeer, his life was closed, not indeed in the beginning of his usefulness, but in the very springtime of a fame adequate to his great deserts. The process within reach of HENDERSON, was more arduous and hazardous, than the one which BESSEL—from the nature of his instruments—could command; but happily the comparatively large parallax of the star gave him early confidence in a result, which otherwise might have seemed ambiguous. That parallax is nearly *one second of space*, which shows a distance of only 240,000 times our remoteness from the sun, or one through which light

would pass in *three years*. Unfortunately, there is yet no settled opinion either as to the actual interval between the two stars of α Centauri or their period of revolution. According to one estimate, they have an interval about ten times greater than ours from the sun, with a period of seventy-seven years; and, according to another, an interval more than twice as large with a period of 290 years. Assuming, in the meantime, the latter elements, we behold two suns rolling around each other, a little more apart at their greatest elongation, than Uranus from our luminary, but at their least distance not so far asunder as our earth from the same orb. And in either case, the mass of the stars together, is about three-fifths of the sun's. This instance, as well as that of 61 Cygni, shows the existence of what I have often hinted at—viz., great varieties among the stars as to magnitude; but we may go yet farther. Dividing a substance of the volume of the sun into two equal spheres, we should have a surface—the sum, viz. of both their surfaces—about equal to the existing surface of the sun (the same *bulk*, be it observed, may have very different amounts of *surface*, according to its *form*). We should expect, therefore, from α Centauri, notwithstanding its smaller *mass*, the same amount of light that our luminary could give at that distance, provided the double star had the same *density* and the *same intrinsic power of giving out light.* But, instead, it

has more than double the light of our sun if removed to the position of α CENTAURI: so that we have again another cause of uncertainty as to the stars—viz., a variety, in all probability, in their powers of emitting light. HENDERSON subsequently discerned—on the comparison of observations made with that end—that there must be a parallax in SIRIUS; and he fixed it at 0″.230. If the estimate of this astronomer is correct,—and the doubt wholly lies in considerations relating to the authority of the instruments he employed, — SIRIUS must be more than four times farther off than α CENTAURI; and yet its illumination is vastly superior. Calculated on these data, its *intrinsic brilliancy* is upwards of sixty times that belonging to our sun—supposing it to be of the same actual magnitude: so that, if the difference of intrinsic splendour does not amount to this quantity, the *size* of SIRIUS may much more largely exceed that of our central orb, than those of 61 CYGNI or α CENTAURI fall below it. But in either case — whether we attribute the variety manifestly existing, to *volume* or to the *power of giving forth light*—nothing can be inferred therefrom invalidating our previous general conclusions as to the distribution of the stars. These depended, not on the conception that all the stars are fashioned in the mould of the sun; but on the fact, that unless there is a variety of magnitude next to inconceivable, apparent

size must—*in the main*—be an index of comparative distance.

III. I have lingered not unwillingly among these interesting fields; but the space already occupied warns me that it is fitting to close. One other point, however, connected with these pairs of suns, is so singular, that I anticipate my reader's pardon though I detain him a moment longer,—I allude to their *colour*. It has been long observed that the stars shine with different colours; for the diversity is apparent to the naked eye. Among those of the first magnitude, for instance, SIRIUS, VEGA, ALTAIR, SPICA, are white; ALDEBARAN, ARCTURUS, BETELGUEUX, red; CAPELLA and PROCYON, yellow. In lesser stars the difference is not so perceptible to the eye, but the telescope exhibits it with equal distinctness. It is likewise far more striking in countries where the atmosphere is less humid and hazy than ours: in Syria, for instance, one star shines like an emerald, another as a ruby, and the whole heavens sparkle as with various gems.* Now, this attribute of variety of colour distinguishes also the double stars,

* There is no doubt that, in the course of long periods of time, stars change their colours. SIRIUS was celebrated by the ancients as a red star, now it is brilliantly white; and other changes have occurred of a like nature. It is not my purpose now to speculate regarding the causes of these variations.

which, indeed, was to be expected; but the *association* of these colours presents a new and remarkable phenomenon. Struve records that, in at least 104 binary systems, the two stars exhibit the *complementary* colours, that is, the colour of one constituent belongs to the *red* or least refrangible end of the spectrum, while that of the other belongs to the *violet* or most refrangible extremity,—as if the entire spectrum had been divided into two parts, and distributed between the two companions. It has been supposed that this phenomenon is the mere effect of contrast, or of an optical delusion depending upon the well-known law, that when the eye has looked for a time on one bright light, it is inclined to clothe any smaller light near it with the opposite or complementary colour, for the sake of relief. The explanation is plausible, but it will not stand *testing*. In the first place, the law, if true, ought to be universal: whereas we find many systems similar in relative magnitudes to those wherein the contrast appears, in which *both* stars are yellow, or, although of other colours, still both belonging to the *red* end of the spectrum. Secondly, if the *blue* or *violet* colour came from contrast, it ought to disappear when the *yellow* star is concealed. Now, Struve refers to the three stars composing 0^2 Cygni. The larger is of the fourth magnitude, and very *yellow*, while the others, which are of the fifth and sixth magnitude, are *blue;* and *though the first be hid, these two*

preserve their blue colour. The double star, β Cygni, affords also an emphatic confirmation of the truth: indeed, I cannot see those stars blazing, one with its yellow, the other with its blue light, and encourage the optical hypothesis for one moment. The constituents of β Cygni are considerably apart, and may be divided by an ordinary telescope. By means of a thin slip of darkened brass or copper, hide the one star, and note the colour of the other. If the yellow star be hid, its companion loses nothing of its peculiar splendour; and if one obscures the blue star, the other radiates precisely as before. Whatever the origin, then, of this mysterious power, on the part of such binary stars, *to divide the light*, or however it may be connected with the process which brought these systems into being,—no shadow of doubt as to its *reality* remains. And think of the novelties, the peculiarities, which the existence of double and parti-coloured suns must cause to the planets encircling them! "It may be easier suggested in words," says Sir John Herschel, "than conceived in imagination, what a variety of illumination two stars—a red and a green, or a yellow and blue one, must afford a planet circulating around either; and what cheering contrasts and grateful vicissitudes, a red and a green day, for instance, alternating with a white one, and with darkness, must arise from the presence or absence of one or other, or both, from the horizon!" All the products of

the material constitution of this earth, the character of its living families, perhaps the action of its magnetic and other influences, are co-ordinated and adjusted to the regular succession of night and day, or to the supply and nature of our solar light. No such families, then, none bearing other than remote analogies to ours, can exist in planets engirdling such double suns. They, too, are surely the abodes of beauty and harmony, but their features are hidden from man—perhaps for ever. And who, after all, would grieve although there be some enclosed spots—quietudes in creation, which may lie unexplored, unpenetrated for ever; who that has felt the soft healing of evening, can regret that, even in the intellectual world, there are regions into which faintness and weariness may sometimes flee, and take shelter and repose, away from the scorch and glare of oppressive light! Sweet and inviting mysteries—among whose gentle shadows Hope and Fear, and all unnamed yearnings, tremblingly advance, and find or fashion for themselves images of purity, convictions of immortality, vistas of a Life to come, through which the soul may wander freer and greater than now, "having gained the privilege by virtue!"

THE existence of pairs of stars combined into physical systems might induce one to expect—prior even to their positive discovery—that associations similar in kind, but of more complex and loftier orders, would be found in the sky. We do not accordingly receive the intelligence with surprise, that *triple stars*, though far less numerous than binary combinations, are likewise abundant; and that these in their turn only lead us upward to schemes yet more imposing. The reasoning, too—depending on considerations of *probability*—which induced HERSCHEL to attribute to the double stars a *physical* connexion, is evidently more powerful with regard to these higher associations, for in proportion to the number of the stars so associated, is it unlikely that the phenomenon can be an apparent or optical one, or the result of chance: nay, it was the existence of that remarkable

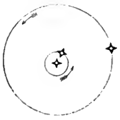
but very complex combination—the PLEIADES, which led HERSCHEL'S predecessor in this course of speculation—the Englishman MITCHEL—to suspect that no such assemblage can be fortuitous. By surveying what is known on the subject, we shall ascend to contemplations of singular interest.

I.

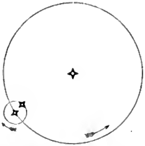
Of triple stars, there are several interesting and well-ascertained examples. The beautiful orb ζ CANCRI, of whose character and period I have already made mention, has in its immediate neighbourhood another star quite within those limits of distance which justify our attributing to the *three* a physical connexion; and the motions of the third body have been detected and followed so long that we can infer its period. The two close orbs have, as stated in the table of page 153, a period of fifty-eight years; but the revolution of the third occupies about 620; its distance from the two is of course considerably greater than the interval separating them—upwards of six times greater. The star ξ LIBRÆ is another instance of a physical system—the period of the two close stars being 105½ years, and of the other 1469 years, or almost exactly fourteen times longer. In 12 LYNCIS we have a third system, where the periods are 590 and 8160

years—the one likewise nearly fourteen times longer than the other. ι CASSIOPEIÆ is another example, and in this and the two cases immediately preceding, the stars move *in opposite directions:* so likewise with others, the details of which I need not enumerate.

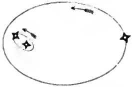
It is difficult to represent distinctly the exact courses of these stars. As with binary systems, it were incorrect to imagine the two orbs revolving around a third; nor must we assume any arrangement akin to this to be the true one. The system in this case, as in similar ones, is balanced around its *centre of gravity*—an invisible point to which the several motions must in strictness be all referred. It is only then, with a view to express more easily the cycle of the relative positions of the several bodies, that the following diagrams are admissible; but so regarded, they cannot lead to grave misapprehension. Under such reservation, the system ζ CANCRI—supposing the orbits circular—may be exhibited thus:—



Or, taking the distant star as the fixed point, ξ Libræ as follows:—



But, though these diagrams show something of the *average* relations of these grand co-equal orbs, we shall not rightly apprehend the case, without introducing another element belonging to such combinations. The orbits, as with the binary systems, are *elliptical*, not circular; so that the actual relations of a triple star would appear in our third figure:—



When speaking of the double stars, I offered some general remarks on the changing distances of these orbs; and the effect of such changes on schemes of planets connected with them. Let us look again at the subject, in reference to the more complex systems now before us.—

The result of the *ellipticity* of the orbs of the closer pair, within the large curve of the diagram immediately preceding, is — as I have already explained—to give a planet rolling around either sun, *two sets of seasons* —one depending on its own revolution or year, and the other on *the revolution of its sun;* for during this latter cycle—fifty-eight years in the case of ζ Cancri—it might be carried from a distance from that neighbour orb, as far as Neptune is from our luminary, to a proximity as great as Venus enjoys. In reality, here are years with their varying seasons, of different lengths, inseparably intermingling; nay, the course of the shorter year can be reckoned an *incident* only—a recurring variety—within that larger one, which doubtless always comprehends many of its returns. As the grand summer and winter succeed, there must come and pass away, numbers of minor periods of comparative life and luxuriance, diversifying that longer course; but only when the planet's summer coincides with the summer of its sun, will the glory of its seasons attain its culmination. In the scene before us there is, however, yet another element. Passing slowly along a career far more majestic, another orb is advancing, with a cycle of seasons grander still. That orb brings its *third* summer to superadd to the foregoing complexity—one which, in the case we have spoken of, arrives but once in six hundred years; and who shall picture or conceive

the effects on all life, on all action, on every internal arrangement of these orbs and their dependents, when, in virtue of the mechanism they constitute, the three suns attain their greatest proximity, and shower on each other their most abundant influences! Nor are cycles thus momentous, limited in their periods. I spoke before of MIZAR and ALCOR. One of these is a double star, and with the distant ALCOR, that inferior system forms a scheme such as I have just described, except that its grand year—that of intense summer and deepest winter—may return only after 180,000 of our terrene units! Would we seek an analogon amid phenomena of the earth, to alternations thus stupendous? There is, indeed, no point of precise resemblance; but can one unrol that mysterious volume of which our rocks are the various leaves, without discerning indications, of what also may be grand summers — periods of intense, all-vivifying heat—under whose beneficence a tropic vegetation covered the drear regions of the Poles? In a previous page I used the word *bouleversement* or *catastrophe;* and truly, when one thinks of the immense width of fluctuation inevitable on provisions like these, or of the opposite conditions of every member of such a system in different epochs of its existence; still farther, if—as alone we know the remote past, or even the larger relations of the present—fragments, rapid glimpses of moments far apart, or of detached portions of such a

system, were all that rested under the eye, how could the word catastrophe be avoided, on the idea of something diverse from peaceful and solemn Law, which by overthrowing order had instituted disturbance and change? Yet, in the deep quiet of the night, look at a triple star, and with your reason follow the motions of its orbs! So would confusion vanish and perplexity be felt no more, if, from a height superior to that which is his summit now, Man could behold unwinding, the full destinies of the World.

II.

Ascending from triple to higher orders of combination, the same great law prevails. There is one quadruple system of peculiar interest. Near the superb orb VEGA, the first star in the LYRE, is a small one of ambiguous aspect. Supposing VEGA the apex of a triangle, the star I refer to is at the base, and nearest our zenith. Look at that star attentively: it is about the fifth magnitude or less; but it appears *oblong*, or with a *spur*. The telescope soon explains this;—it is *a double star*, whose constituents are unusually apart. Examine more narrowly however, with increase of magnifying power. Each of the companions now seems double; so that the combination is really a *quadruple system;* and this is confirmed by the fact that the two large stars

have a *common proper motion.* The orbits of neither of the binary systems—far less of that of the higher system—can yet be fixed; but supposing them circular, an approximation to their periods may be hazarded. The most recent results give 1080 and 2090 years as the probable times of revolution of the secondary systems; from which, a well-known dynamical theorem enables us to infer, that the general revolution cannot be accomplished in less than six thousand of our centuries! How entirely one is lost, when attempting to comprehend the conditions, interior arrangements, and majestic evolutions of progressions like these! But another description of speculation is opened by this star. It requires a very good telescope to divide ε and 5 Lyræ into pairs. The stars themselves are separated from each other very easily, but it is not easy to see their composite character, or the *quadruple* system. So soon, however, as this is seen, the idea forcibly presents itself, that through the inferiority of the instruments employed, many stars which are really multiple, escape analysis. And this, in all probability, is the cause of the doubt hanging over the observed courses of some binary systems, in reference to their agreement with the law of gravity. We are perhaps looking in such cases not at a *double* but a *triple* star, or instead of a *triple*, at a *quadruple* or *quintuple* star,—some one or more of the orbs not being resolved, by reason of the close proximity of the stars composing them; and

if this were true, the bodies could not appear to move exactly as they would, supposing the unresolved stars to be really single. So rapid are our advances in this line of inquiry, so very rapid alike the increase of the delicacy of instruments and of precision in using them, that the process which discovered the planet NEPTUNE may soon be effective in decomposing orbs, on whose simplicity and singleness the highest optical powers have hitherto thrown no shade of suspicion. Thus, as we advance, refinements formerly evanescent—or *residual*—ever rise into important positive agents of discovery.

Ascending from the quadruple systems—of which I have given ε and 5 LYRÆ as an illustration and example, we meet with others of all degrees of complexity, pronouncing the truth, with one accord, that unusual proximity indicates physical relationship, and systems overruled by the law of gravity. It is not yet in the power of astronomy to lay down the exact courses of these very complex systems; but it is not possible to doubt that the PLEIADES, whose beauty and singularity attracted the notice of MITCHEL, form a grand mechanism, whose individuals are united with each other more closely than with the general mass of the stars. Can it be that the disappearance and reappearance of individual orbs is connected with such evolutions? Does the lost Pleiad,

for instance—the sorrowing MEROPE—refer after the fashion of that beautiful mythology to the retirement of a star formerly visible?—As with the PLEIADES, so with the other small groups in LYRA, TAURUS, the *præsepe* in CANCER, &c.: but our course stops not even with these. Turn again to that gorgeous mass in the sword handle of PERSEUS—a group whose glory is so dazzling—can we fail to discern even there, emphatic indications of system, the presence of some august mechanism before whose immeasurable periods and stupendous purposes man can only pause, and in silence express his awe. Loftier still, observe those *clumps*, those cumuli of the Milky Way, made up of stars in myriads beyond reckoning, yet likewise distinct clusters, masses apart in so far from what environs them, and therefore enjoying a structure—a life—that is especially their own. Oh! how small our attainments, how poor our best imaginings, compared with what Reason indicates, as belonging to combinations like these! But courage, and not despondency, should arise, when we are told of the immensity of the unknown. Forgetful of his appointed function, reckless of his destiny, unworthy even of his own immortal achievements—shall man turn away from the labour of ages because of the shortness of his individual life, or because he cannot scale the entire mountain, lie down and take sleep at its base? Listen rather to a wiser strain:—'How much,' says Sir JOHN HERSCHEL, 'is

escaping us! How unworthy is it in them who call themselves philosophers, to let these great phenomena of nature—these slow but majestic manifestations of the power and glory of God—glide by unnoticed, and drop out of memory beyond reach of recovery, because we will not take the pains to note them in their unobtrusive and furtive passage, because we see them in their every-day dress, and mark no sudden change, and conclude that all is dead because we will not look for signs of life, and that all is uninteresting because we are not impressed and dazzled. To say, indeed,' he continues, 'that every individual star in the Milky Way, to the amount of eight or ten millions, is to have its place determined and its motion watched, would be extravagant: but at least let samples be taken—at least let monographs of parts be made, with powerful telescopes and refined instruments—that we may know what is going on in that abyss of stars, where at present imagination wanders without a guide!'

A theme, astonishing even as our former one, thus again appears. We have, it is true, discerned only the earliest indications of its nature, but they are indeed most marvellous. Amid these skies there is silence no longer, but activity everywhere, and stupendous evolution; and as we ascend through their various mechanisms, durations arise before the view—thronged with majestic purposes—ever vaster and vaster, until as before with Space, the idea of Time is stretched out until it vanishes, and in its stead, a form, having the semblance of Eternity, appears. Perhaps, when the Eye has thus been strained all around, and Reason discerns that no sooner is one grandeur apprehended, than others rise up behind it which dwarf its loftiest proportions,—in moments of half-conscious dissatisfaction, because of the very wondrousness of this universe,—we may not be indisposed to put the question—What means this ranging of the human mind, on and

on, seeking an end only to find that all is endless? Or for what object, and by what energy, is that thinking principle which, with its varied activities, we all of us so lightly wear, induced to ascend so high—approaching even the portals of the Infinite? Sometimes, to an inquiry whose relations are at once profound and far-reaching, a thought has occurred to me in reply, which I fear I shall only imperfectly expose. The power achieving such triumphs—that human Spirit—though now, for inscrutable purposes, placed within the conditions of the finite, is yet an essence infinite, immortal,—stamped indelibly with the characteristics of an immortal nature. Now, while it belongs to our mysterious imprisonment or dwelling within finitude, that we discern the universe as finite beings, or that nothing is apprehensible by the intellect in the first instance, unless clothed in the forms of Space and Time; it must not be forgotten that these forms are necessary simply *because* of our finitude; for to Him who is absolute and eternal, there is neither succession nor distance;—whatever is, has been, or shall be, rests as a thing that passes not, under his unchangeable consciousness. May not, then, these struggles of ours simply be an effort inseparable from our complex nature, to ascend through division and transiency to that loftier form of cognition which belongs to its essential infinitude? If we accept no boundary within space or time, but—overpassing

all limits—stride onwards to the fathomless and everlasting, is it not an expanding of the Spirit in opposition to its bonds—an expression of its longing to be disenthralled? Those Heavens are very glorious, and their voice deep as the Ocean's, but they cannot contain an Immortal; like a shell, they only murmur of a far off home. Signal the happiness of Humanity to be environed by an imagery so resplendent, but happier still, that amid the weaknesses—the very ashes of our being, the power remains to apprehend that imagery as a SYMBOL; and that 'Thus'—as our priest-poet has sung—

——— IN A SEASON OF CALM WEATHER,
THOUGH INLAND FAR WE BE,
OUR SOULS HAVE SIGHT OF THAT IMMORTAL SEA
WHICH BROUGHT US HITHER,
CAN IN A MOMENT TRAVEL THITHER,
AND SEE THE CHILDREN SPORT UPON THE SHORE,
AND HEAR THE MIGHTY WATERS ROLLING EVERMORE.

Thou mad'st the moon to divide the [illegible]
Thou makest darkness & it is night!
At thy step, existence comes forth, oh Jehovah!

CHAPTER V.

GRAND MOTION OF THE SUN, AND OF SINGLE STARS. —PROBABLE SYSTEM OF OUR ENTIRE GALAXY.— QUESTION AS TO THE NATURE OF FORCE.

THE investigations explained in last chapter have established a fact of paramount importance. They have confirmed the suspicion of many able and prophetic minds, that wherever we discern among the stars an especial closeness or *grouping*,—*there* we may safely assert the presence of special system and mechanism, and that the orbs of the group roll around their common centre of gravity, in obedience to the law governing the planetary-orbits. And farther, they entitle us to state it as probable, that, even among those larger groups, such as the massive parts of the Milky Way, there is a similar connexion, although the motions which would distinctly manifest it must be too slow and remote, to permit of their courses being recorded during the whole endurance of our race. But, after such truths are accepted, there remain many inquiries unresolved

concerning our scheme of stars: for instance, what is the condition of these single suns—orbs connected apparently with no minor system—individuals only of that complex and marvellous scheme? It is evidently not possible to reach any general conclusion until the point now referred to has been examined; but our investigations will not terminate with its resolution.

I.

The luminary around which our world and its companions circulate is a single star; and as we must know its habitudes best, it is they that should lead us to our earliest acquaintance with the condition of such members of our galaxy. The problem, however, is a very complex one, and we must rise to its full height by steps.

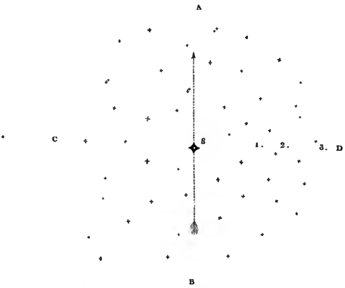
I. If the sun, as a separate orb, had been affected by some peculiar motion in the midst of a cluster of stars at rest, it would be easy to discern, during the lapse of ages, not merely the existence of his motion, but also its precise direction and amount. Suppose, for illustration, a traveller advancing towards any regular arrangement of objects — say a line of trees or of columns, and proportionally receding from another; he would detect his motion—even though he did not

feel it—in this wise: the objects in front would gradually *widen out*—*i. e.*, the intervals separating them would appear larger as he approached them; while for the same reason the group he was leaving would appear *closing in*. Of this kind, indeed, are the grounds of all our judgments regarding the more familiar celestial motions: we accept the rotation of our world on its axis because of the grand apparent diurnal revolution of the stellar vault; and the fact that the earth is a planet moving through an annual orbit, is a mere deduction—sustained assuredly by many analogies—from the apparent motion, through the ecliptic, of the sun. The safety, indeed, of all such conclusions mainly rests on the number of external and independent phenomena, which the adopted solution avails to explain; and it was because his daring conjecture of a grand solar motion comprehended so many seeming discrepancies, that HERSCHEL first offered it as an astronomical truth. Comparing the best older catalogues of the fixed stars with the most trustworthy of his time, he found that, though not large, there were many apparent displacements; that no star, indeed, which had been long and well observed, could, according to common language, be termed fixed; and it appeared, besides, that the supposed motion of the sun towards one district of the heavens, and away from its opposite, accounted for most of the changes of place that had occurred in either

region. In the neighbourhood of a place within the constellation HERCULES, the stars seemed to have been opening out; while at the opposite point of the sky, their mutual distances were diminishing; so that, as in the case of our rude illustration, it might be fairly concluded that the sun is rolling through some mighty course whose direction, during the entire period of reliable observation, has been towards a determinate point in the sky. But HERSCHEL advanced farther. Seeing that if such a motion exists, not merely the stars in particular regions, but all stars in the heavens must appear to change their places, he occupied himself with the recorded conditions of various orbs scattered over the sky; and on examining the nature and directions of their motions, it appeared that in the main they were all drifting away from the foregoing point in HERCULES. No longer, then, did doubt continue in the mind of our immortal countryman regarding this new revelation concerning the structure of the heavens. And assuredly it was most fitting that to him whose unrivalled sagacity penetrated the secret of the multiple stars, tidings should first come of the perfection, the unity of the whole of our majestic system—the tidings that, among its innumerable hosts, not one is solitary or apart, but an essential element of the universal scheme, exchanging sympathies and action with all, and unfolding what these are by its motions.

II. It certainly cannot be supposed that amid these innumerable orbs our sun alone is in motion, but rather that his august course is a type of what is inherent in every star. But if the stars around us are in motion, how can we detect the sun's—how are we entitled to infer—in the terms I have been explaining—a motion in the sun, from displacements which, after all, may originate in actual motions of the luminaries surrounding him? Herein indeed lies the true difficulty of the inquiry; it is the difficulty of distinguishing and separating what may be *positive* motions of the stars, from motions *apparent* only, or owing to the progression of the sun, which demands for the solution of this problem so much excellent judgment and subtle analysis. But my reader will readily comprehend the principles by whose aid an obstacle so serious has been removed. In the first place, I beg attention to the subjoined diagram —so that the actual nature of the inquiry be apprehended. It is easy to see that if, according to our former hypothesis, these points environing the sun at *S*, were motionless, the existence of his course towards *A* would without difficulty appear; but farther, inasmuch as the motions of these various stars, scattered through all the regions of space, must *be various*, while the steadfast course of the sun must produce a distinct, consistent, and universal effect on their apparent positions, is it not evident, that amid much variety and some apparent

contradiction, there would yet—because of the sun's motion—appear necessarily a *general* tendency, or *drifting* away from a certain point? The apparent influence



of the solar motion on the places of the stars must extend through all the skies; while there cannot be supposed, *in the first instance*, any remarkable uniformity in the courses of his compeers; so that the problem really is to extricate *uniformity* from amid *variety*—to separate from those multiplex apparent changes, that one universal element which must exist and be found uniform within them all. Now, in the present condition of our

knowledge, no idea can be formed of a mechanical system that would impress on the motions of so many stars a regular course *in one direction*. If they are in motion, it is most probably around some grand centre, or along other paths determined by the energy of gravity; and, judging by our sole experience—viz., actions of this nature on the earth and within our solar system—it is not possible to suppose, at any given instant, even a remote tendency to uniformity in the *direction* of motions so very numerous. One star, for instance, may move southwards; but elsewhere one will move northwards: in another place we might find an eastward motion; but certainly that would be counterbalanced by the westward course of some other star. If, indeed, a very great number of stars were discussed, we might rationally expect that their motions would compensate each other; or that—placing those towards the north against those towards the south, and so with the other directions—the result would simply be, *nothing*, or an accurate *balance* of tendencies. A conclusion so satisfactory could not, of course, be attained *absolutely* by any special investigation; but in all probability every inquiry would approach it, in exact proportion to the accuracy of its data, and the *number and varied positions of the stars* of whose motions it took account. Although we are certainly not entitled to expect that any actual inquiry—imperfect as it must be—would evolve as its result,

an absolute *zero* or *balance* of motions, we must adopt that as the *aim* of all theories; and therefore the problem as to the solar motion is this—to find a point in the sky, *such*, that if our sun be supposed to move towards it, and the effects of his motion be deducted from the apparent motions of the surrounding stars, —the *residuum*, which is the amount of their *proper* or actual changes of place, shall be as near as possible to *zero*:—in other words, that the *balance* of the proper motions of the stars—thus computed—*shall be more perfect than if we imagined the sun advancing towards any other point.* To reach a *perfect* or final solution of such a problem is perhaps impossible; nay, even its ultimate solution might leave some grand *residuum*, indicative of a general tendency—pointing emphatically to some loftier system: but the chief hindrance to a final result is the absence of correct knowledge of the proper motions of an adequate number of stars. The treatment of the entire problem, indeed, demands especial management; for likewise, in proportion to the *distances* of the stars, will their positive motions be distinctly revealed: and the marvel is, that Herschel, with his imperfect data, could arrive even at a proximity to the truth he sought. His result, however, has been thoroughly confirmed. Argelander, of Bonn,—one of those many German astronomers who combine signal facilities in generalizing with precise habits of observation, has

brought the lights of recent knowledge to bear on the question; and his conclusions uphold HERSCHEL'S. Not only taking into view a much greater number of orbs than—in the time of his great predecessor—were known to have precise proper motions; ARGELANDER farther computed the effects of the *position* of each star in the sky; and he was enabled likewise to allow for their *comparative remotenesses* by an hypothesis which entitled him to arrange them into three great orders of distance; (the orders in the diagram, 1, 2, 3.) It was thus in the power of this geometrician to state with unexpected precision, the influence of a solar motion towards any point, on the apparent motion of the stars; and therefore to select a point, which—better than any other—should fulfil the fundamental condition, whose nature I have endeavoured to explain. ARGELANDER was followed by another mathematician, who treated similarly a number of stars omitted by the former; and OTTO STRUVE, taking a fresh view of the subject, and drawing his facts from the grand storehouse at Dorpat, obtained a third independent result. Combining all these investigations, it seems the most probable conclusion, that the sun is moving towards a point in the heavens whose position in right ascension and declination is below; viz.:—

R.A., 250° 9½′
N.D., 34 36

And we can now add the following very remarkable confirmation. The stars depended on by ARGELANDER and OTTO STRUVE are all visible in our northern regions; but it occurred lately to Mr. GALLOWAY that it might be well to inquire into the motions of southern stars,—whether they concur or conflict on this subject with the indication of the northern ones: and in a memoir in the *Philosophical Transactions* for 1847, distinguished throughout by his precision of language and peculiar lucidity of exposition, he has explained his grounds and methods, and stated their result. The point determined by him has the following position—viz.:

R.A., 260° 0¼′
N.D., 34 23½

Almost identical with that indicated by the northern stars! But observe the sagacity of the extraordinary man who led in this inquiry. None of those data were before him, which in later times have conduced to a result so satisfactory; the subject lay all *in the rough*; and yet so clear and correct was his judgment, that the point he selected differed from the foregoing only by a very small quantity. He announced, in 1783, a determinate motion of the sun towards the region of 257° in right ascension, and 25° north declination!*—As to the

* My reader's conception may be here rendered much more distinct by looking for the places indicated, on any celestial globe.

subject itself—the grand motion of the sun as well as its present direction, must be received now as an established doctrine in astronomy. And so with the stars his compeers: they too in vast courses are rolling through space, ever passing into new collocations. How august such a scene—how remote from our usual notions of these heavens! Because the very orbs that shine on us, also shone over the Chaldeans, we spoke of their changeless rest — of their arrangements as eternal! Alas, no! Eternity—changeless endurance; these belong to one Being alone, and ever as the shadow moves onward on the dial, the bright but transient hieroglyphics of these heavens transform and flit by, so that when time shall be no more, the writing of that mystic scroll may have unfolded somewhat of the fulness of his inscrutable Nature!

III. One other point remains, also of consummate importance. Can we reach any conception of the velocity or amount of this solar motion? With what energy is our system sweeping through space?—The first definite attempt to ascertain this velocity is due to BESSEL; and formed part of his investigation regarding 61 CYGNI. The apparent annual motion of this star having an extraordinary correspondence in *direction*, with that which seemed due to the motion of the sun, BESSEL conceived that its change of place is probably *altogether owing to that motion;* in other words, that 61 CYGNI appears to move

because the sun is moving in the opposite direction. Now, the distance of 61 Cygni having been ascertained, it was easy to convert the portion of the sky which it seemed to traverse annually into *miles;* which on the foregoing supposition would evidently be the annual velocity of the sun. But the hypothesis in question cannot be accepted. There is no likelihood whatsoever that 61 Cygni, or any other star, is in absolute repose; so that its apparent motion must contain its own proper motion, as well as the effect of the sun's—quantities which, in the case of any *one* star, it is impossible to disentangle. From the investigations, however, of Otto Struve, we obtain a much more reliable determination. It is not difficult, according to the views of this astronomer, to calculate the apparent magnitude of the sun's motion, if seen from the average distance of stars of the first magnitude:—he would appear to traverse a little more than *one third of a second of space* annually. But the radius of the earth's orbit, viewed from the same distance, appears only *one-fifth of a second* in magnitude; hence the sun must traverse in *his* orbit upwards of one and a half times our distance from him, in the space of one year, or about *one hundred and fifty millions of miles:*—a rate so swift that it would carry us to the nearest known star, α Centauri, in 130,000 years, and to the boundary of the mighty sphere containing all the stars of the first magnitude in about 800,000 of these same units. In 4,000,000

of years — were our great luminary rolling onwards persistently in a straight line—we might be conveyed to the extremity of those depths to which the unaided eye can penetrate, and in twice that period into the midst of the superb spot in PERSEUS. Immense, indeed, such durations, when laid beside the span which may confine the terrestrial destiny of our human race; but they are small in comparison with what the universe elsewhere reveals—nay, they are surpassed by what has been occupied by the annals even of our globe. If geology is not the sheerest fable—if we are not to return to the old conceptions, that its rocks and entombed creatures have been laid down there as the most mocking of enigmas, enigmas that seem to have a meaning and yet have none, —then, the largest of those periods of which we have been speaking, can only be a part of the last of those changes which are recorded on the surface of our world. Nay, if Sir WILLIAM HERSCHEL is correct in some of his estimates, our grand orb might sweep to the remotest outskirts of some regions of the Milky Way in eight hundred millions of years; and certainly during the greater part of that overwhelming duration, our chief existing mountains have been in being, rearing their peaks towards different constellations, and surviving in all their littleness and fragility even these immense transitions. I do not specify such possibilities as marvels merely, or curious but barren speculation;

for something akin to them appears to have affected the whole destinies of our planetary system. They afford a glimpse of influences bearing on the fates of our sun and his dependents, remarkably similar to those which, in a former discussion, we signalized as a consequence of the eccentricity of their orbits in the case of the double and triple stars. The spaces through which our scheme is being conducted by that majestic course, are characterized by no uniformity; for in one district the stars are sparse, while elsewhere they are densely concentrated, as in the more massive parts of the Milky Way. At present the sun is amidst a thin and chill region; but in the course of centuries it may emerge again—passing within aggregations of orbs, where light and heat might be showered on us more intensely, some hundred-fold. It is not my purpose now, to discourse curiously of such transitions; though it cannot be passed without notice, that in the judgment of the eminent POISSON, they furnish a sufficient cause for those puzzling variations in the ancient temperatures of our globe: but in presence of cycles so immense, bringing with them modifications quite inconceivable, of all environing circumstances, can one fail to discern, how—throughout this universal realm of nature—the highest order cognised or cognisable by man is subject ever to profounder ordinances enveloping and containing it as a subordinate part? Precisely, indeed, as knowledge has advanced, have our views in

this direction been enlarged. Once the thunder was a prodigy, yet it belongs to powers which beneficently nourish whatever is beautiful on the earth. The raging hurricane springs from the delicious breezes of the tropics, and is an essential portion of the harmonious system of the winds. Grand thoughts and deeds, as well as physical marvels, spring up without apparent parentage in our world; but angelic natures penetrate to their birthplace, and by the sight are strengthened still farther to adore. Yet not even these elevated and purer beings have searched all the chambers of that inscrutable light. Doubtless man's largest infinite—even that which speaks of the form and career of his galaxy—is in their apprehension a bounded and oft-trodden plain; but on turning to that light, law seems rising above law, the higher enveloping all the lower—the last ever the grandest and farthest reaching, until the series ascends to the invisible, and enters the hidden sanctuary of GOD.

II.

The most arduous problem connected with the mechanism of our galaxy now opens before us. The mind rests no longer with the phenomena of minor collocations—multiple stars and groups like the PLEIADES—which enrich its interior imagery; but taking the career of the sun as illustrating the destiny of the

unnumbered orbs which environ him, we adventure on the inquiry whether aught may ever be discerned concerning that universal system; whether the courses of its stars are affiliated; and what is the aim of their wondrous relations? No marvel, indeed, that in reply, I can offer but few positive trophies; though here, also, unwearied intellect is at work.

I. The point which first of all may receive satisfactory elucidation, is perhaps the *shape* and *magnitude* of the orbit of the sun. As yet we know only the present direction of the motion of that luminary, and its approximate speed; but if its course be curvilineal, that direction must fluctuate; and after the lapse of another half century, the nature of the curve may be indicated by these fluctuations. Postponing to an after period the attempt to solve that problem definitively, we may, however, even now, indulge in a speculation on whose behalf at least some degree of probability may be challenged. If the orbit be either really or approximately circular, the direction of the motion at any one moment would point out *the direction of its centre.* Supposing a great plane to be drawn through the sun, at right angles to the line between him and the foregoing point in Hercules, we know, from mechanical considerations, that the centre of the orbit must be in or near that plane; and if other considerations could

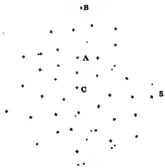
indicate another plane, in which also, the centre must lie, then the intersection of the two would determine approximately its position in space. But reflecting again on the nature of the Milky Way,—how that great plane is the massive or preponderating portion of our galaxy; and further, that in every mechanical system it is the tendency of individual parts to gravitate towards the densest regions of that system; is it not likely that the centre of motion of the sun, as well as of the other orbs around us, lies in or near the plane of the Milky Way? But these *two* planes intersect in one place in the constellation PERSEUS; and considering the especial riches of this remarkable region, may we not find there the most probable centre of the orbit of the sun? Should this conjecture be confirmed, the radius of his majestic course would exceed his remoteness from our earth, some ten millions of times! One other indication of the scale on which the stupendous plan of these motions has been framed!

II. But on this arduous subject we must seek aid from the proper motions of the other stars—those motions which are essentially their own, the *residuum* after the effects of the translation of the sun have been deducted from their apparent motions. Alas! that quantities of import so profound are yet so evanescent! Suppose a circle drawn around the heavens to be divided

into 21,600 equal parts,—each of these portions is a *minute* of space; subdivide a minute by 60,—each of these is a *second;* and it is only through one-third of this last almost infinitesimal space, that our sun, if viewed from the sphere of stars of the first magnitude, would appear annually to move! But, notwithstanding their minuteness, these quantities cannot escape detection and scrutiny, and must in due season unfold the nature of the majestic system which evolves them; nay, in the hands of one ingenious man, M. Mädler, of Dorpat, they have already formed the basis of a large and interesting speculation, which, though it does not reach the heights of all truth, has signalized a phenomenon too remarkable and unexpected to permit us to cast it hastily aside. It will be remembered that, during our discussion of the double stars, I noticed an essential difference between systems so constructed, and others like our planetary system. In both of these, and, in fact, in all systems whose motions are accordant with the grand principle of gravity, the orbs really move around the *centre of gravity* of the system—the point, viz., around which all the masses composing the system are balanced. But since the magnitude of the sun so immensely surpasses the sum of all his attendants, the point in this instance is quite near the sun's own centre; while in the case of a double star, whose constituents are never extremely unequal, it lies

somewhere *between* the associated orbs, but within neither of them. The planetary system, therefore, is an arrangement of comparatively small bodies revolving around a *central* ORB; but, on the contrary, the double, triple, quadruple, &c., stars, are schemes whose courses are referable only to a *central* POINT. Now it is with this latter class alone that the general system of our galaxy can be supposed to have analogy; for among the fixed stars there is no disproportion of size which would allow the conception of one of them controlling even a few of its companions—far less all the constituents of the heavens; and the belief of some minds, in an orb sufficiently majestic, but invisible to the human eye, is only one of those many fancies characterising speculations not founded on observation. Between the two classes of systems, however, there is a farther distinction of yet deeper concern. Wherever we find a central orb having the functions of our sun, the immense proportion of the attractive energy exercised by the system is at the centre; and therefore the closer a planet or subordinate body is to that centre, the greater the intensity with which it is drawn towards it. The planet MERCURY, for instance, is much more strongly drawn towards the sun's centre than VENUS is; and to counteract that larger central force, MERCURY must revolve in a shorter time than VENUS, so that it have a correspondingly large centrifugal tendency: and in general, *the nearer a member of*

such a system is to the centre, the more SWIFTLY *will it move around it.* In the case, on the other hand, of a mass or collection of stars of nearly equal magnitude, with motions around a central *point*, precisely the opposite occurs. The sum of all the actions effective on the star *A*, for instance, as well as the sum of all those affective on *B*, in the subjoined diagram, tends in either



case to impel the orbs towards the eentre *C:* but *A* is drawn or impelled towards it with a much *less* force than *B* is; so that, to counteract that force, and thereby maintain its place, *A* need have a *less centrifugal* tendency than *B;* and in general, *the nearer a member of such a system is to the centre, the more* SLOWLY *will it move around it.* A slight additional consideration of the diagram will make it farther evident, that in such a system—whatever the directions in which the stars *really* move—all nearer the centre than *S* would *appear* to move in a direction *opposite to the real motion of S:*

for if any orb *actually* moved in the opposite direction, its *apparent* motion would plainly be the sum of its own motion and that of S; and should it, on the contrary, move in the same direction with S, it would still appear to be *left behind*, because moving *more slowly*. Now, after discussing, with considerable acuteness, the apparent motion of all the stars between us and ALCYONE, the principal orb in the PLEIADES, M. MÄDLER thinks it established that every one of them *has the same direction;* an uniformity so unexpected and dissimilar to the phenomena of the other regions of the sky, that it must have a *general cause:* and—confiding in the principles just explained—he assumes as that cause, that ALCYONE *is near the centre of gravity of our vast system*, the point around which the sun and his innumerable companions are performing their revolutions. It would follow from this theory that the sun's distance from the centre of his orbit is thirty-four millions of times the radius of the orbit of the earth, and the duration of his course about 19,256,000 years! Supposing these numbers no more than probabilities or conjectures, they yet have their important uses; they familiarize the inquirer with that order of conceptions with which, in pursuits so stupendous, he must inevitably deal.

III. But in the light in which he puts it, M. MÄDLER's speculation cannot be accepted; it does not

overtake the complicacy or reach the elevation of the case. That concurrence of so many motions, must indeed have a general and important cause; but the affections of all the orbs he has examined—nay, though augmented an hundredfold, can in nowise be assumed as a key to the mysteries of our extraordinary galaxy. Situated exclusively within that sparse district, enclosed as by a ring, within the Milky Way, they compose but a few even of the orbs which are scattered there: and, towards the massive Annulus itself, far less amid its wonderful, its bewildering prolongations, observation has not stretched at all, or taken account of the proper motions of its luminaries. It is as if, at a star near the centre of the spiral of Plate XII., an inquirer had descried some orderly system comprehending the orbs which are there disposed with comparative regularity; and forgot thereupon, the intractable and wild complexity of the object of which the central mass, however great in itself, is but an insignificant portion. Immersed in the interior of the Nebula—the skies over his head sparkling with the stars he knows best—the astronomer might for a moment encourage that delusion: but remove him to the height from which we inspect his galaxy; show him its fantastic arms thronging with star-clouds, each one of which might be mistaken for a universe; cover with your finger the little circle beyond which he knows the proper motions of no star, and assuredly the ambition

will endure with him no longer! We have been treating of multiple stars and of groups that seemed complex; nay, in presence of the problem here foreshadowed, *these* with all their beauty and interest, shrink as if into single orbs: oh! more arduous the steps, far more majestic the separate collocations through which we must ascend, ere the dimmest light shall appear concerning the mechanism which inspires with *unity* that involved and unfathomed magnificence! Indeed, it is a marvellous fabric!—orb intertwining with orb; multitudes uniting through sympathies, and forming a star-heap; and these again combined by relations, definite, harmonious, though yet hidden from man, into a mass, stupendous, inscrutable as that Nebula! But there is a fact more wondrous still. On the surface of a world which is a mote, and overarched by an infinitude alive with these lustrous forms, man can turn his eyes to his feet, and *there* is the insect with its nest, and the floweret blooming in peace! Yes! if awed by these glories into dread, or fearing amid their surpassing splendour lest a darkness should be thrown around the dwelling of my soul, I revert to that home picture of Luther's, in which he speaks of the little bird that on summer evenings came to his pear-tree at sunset, and sang ever joyously, and without one note of misgiving, because, though great Eternity was above, below, and around it, God was there also.

I SHALL penetrate no farther amid these immensities. I shall not strain my imagination towards loftier regions, leaving to after times the effort to comprehend the relations of the separate clusters, or the starry universe as an aggregate, in which each cluster plays a subordinate part. Reflecting, indeed, on the rapid progress of astronomy, I think that the time may not be far distant in which speculations inapproachable now, shall not appear less real than our existing theories regarding the system of our own galaxy: but retiring from heights which at present are all too dizzy, there presses on me a consideration of a different kind, and of closer interest than is possessed even by researches concerning the habitudes of the stars. Looking at these mighty motions occupying the immensities of Space and Time, and apparently carrying on the vast universe through a course of majestic and ever-varying

developments,—one cannot resist the inquiry—What are the forces which shape and sustain them; not, I mean, as to their technical form and name, but what are they in their essence, and where their place as between the perceiving Spirit and the Divine originating mind? There is, indeed, one inferior question, regarding such forces, on the discussion of which it is not necessary to enter in this present age. I do not speak of these forces as if doubt remained in reference to their *dependence*, whatever be their derived essence. The period happily has long gone by, in which men whose instincts were at the mercy of any trick of logic, could obtain assentient hearers for the doctrine, that such powers are mechanical agencies unoriginated and uncontrolled: but far beyond this, another inquiry lies—What are these forces *as delegated powers*—what, in truth, the signification, physical or spiritual, of a term so common and so important? Now, if we interrogate the external world, or rightly analyze the phenomena which lead us to recognise the existence and character of any separate FORCE, it will be found that there is nothing in them excepting *regular sequence*—the fact that certain events follow according to a definite order. That grand force of gravity, for instance—whence comes our knowledge of it? The planets of the solar system have been found to revolve around their luminary in certain curves and with certain velocities: the order of these motions

we term their LAW; and the cause of that Law is the *force* of gravity. But unless, as indicated by its effects in this regular sequence or order, no *force* of gravity is *perceivable* either in the planetary system, the farther heavens, or around us on the earth. Is that force nothing, then?—is it only a name for orderly succession?—does unconnected but regular sequence make up all we can know of the harmony of the universe? It cannot be! Descending within the mind's interior chambers, I find no conviction so sure of the existence of an external world, as my belief in the reality of POWER —of something that sustains succession, and causes order. Again then, whence this idea, and what is it? —what this attribute with which I endow material LAWS, raising them into FORCES? Now, in my apprehension, the strictest scrutiny can give to these inquiries only one reply. We do not *primarily* connect the idea of power with any sequence, except an act or determination of the FREE WILL; but from such movements of the free will that idea is inseparable. If, therefore—as appears to be necessary—we must explain the progress of external order by the agency of *efficient causes*, this is only a recognition—through all form and transiency—of a creative power, requisite and effective to uphold, renewing the universe every moment, or rather prolonging creation by the persistence of the creative act. And, in very deed—solemn though it be—such is the true and

ultimate scientific idea of the Divine Omnipresence. Law is not even the Almighty's minister; the order of the material world, however close and firm, is not merely the Almighty's ordinance. The forces—if so we name them—which express that order, are not powers, which He has evolved from the Silences, and to whose guardianship He has entrusted all things that so He himself might repose:—No! above, below, around—*there* is God; there, his universal presence, speaking to finite creatures in finite forms a language which only the living heart can understand. In the rain and the sunshine—in the soft zephyr—in the cloud, the torrent, and the thunder—in the bursting blossom and the fading branch—in the revolving season and the rolling star — *there* is the Infinite Essence, and the mystic development of His Will!

PART III.

PSYCHE, OR EVOLUTION.

PLATE X

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CHAPTER VI.

RELATION OF THE FORM AND THE INTERNAL ACTIVITIES OF GALAXIES.—PROBABLE CHANGES OF THESE FORMS.—CONJECTURES RESPECTING THE PROGRESS OF THE MATERIAL UNIVERSE.

IT follows from those relations with the Infinite, which, though partial and dim, are yet the pride and strength of the human reason, that the desire of knowledge is never quenched by attainment, nor—however signal the triumph—the task of inquiry ever ended. That brilliant train of discovery, along which—I trust in my reader's company—I have essayed to travel, might indeed have amply satiated any finite mind; and, as to man, it penetrates alike through time and space, immeasurably beyond the limits which contain the terrestrial concerns or even the duration of his race: nevertheless, no sooner have we apprehended its scope, and been aroused from our astonishment at its stupendous reach, than ambition is fired afresh, and speculation, never at rest, takes wing towards remoter regions.

I.

Although the facts established in the last two chapters are drawn from observation on a limited number of stars, I think they entitle us to conclude generally that every galaxy is a grand dynamical system, in which the separate orbs are united according to the principle of gravitation — manifesting that union through their motions. These magnificent clusters indeed—whether of the simple form of that in HERCULES, or complex as the Spirals—are, like the great oak-tree, superb organizations, where every atom has its essential function and place, and the highest—the ultimate problem regarding them is, in what manner do the various atoms conspire in each case to produce the whole as we see it; with our knowledge of that internal organization, can we now construct or explain the Nebula?

In the earlier part of this Essay, I described with some minuteness the more prominent *forms* of these extraordinary objects; and postponing for the time all thought concerning their interior relations, I attempted to descry whether there were any general laws whose action upon such masses might explain their leading shapes. Traces of such laws appeared. The forms of one large class of them—viz., the *globular*, intimated, in

a way not to be mistaken, the presence and unchecked energy of a *centralizing* power: a second class—those with *hollow centres*—brought as clearly into view the existence of an opposite tendency—viz., the *centrifugal;* and amidst that extraordinary diversity of Spirals, we remarked the play and commingling of both forces with various *relative* strengths—the centrifugal tendency sometimes throwing out the great branches or *whorls* of stars, *so* as to permit no idea of their sweeping *round* the central mass. It is probably on these speculations, or something corresponding to them, that the future work of the telescope will chiefly throw light; and much information may soon be gained by accurate determinations of the *curves* of the arms of these spirals. But supposing all that can be known in this respect to be defined—supposing the relations of these conflicting energies ascertained for every variety of cluster—spherical, hollow, or spiral, the question yet remains, as to the origin or determining cause of such diversity in these relations. Why, in fact, does one galaxy differ from another? Not merely, *what are* the relations amongst the forces overruling these various shapes, but *whence* come they?—It is evident that the form of a cluster of stars must either be the simple and direct result of the mutual affections and concurring action of a mass of orbs influencing each other according to the principle of gravity; or, some foreign and probably remote agency has interfered with

these stars, and exercised an influence over their dispositions and destiny.—Very far are we at the present time from being able to answer such questions, and solve such difficulties, in regard of even the simplest of these galaxies; but although an inquiry cannot be completed, it is never devoid of interest to look at the considerations which may affect its future course.

It need not be repeated, that the most perfect and comprehensive of our abstract sciences, avails us nothing when we come to speak of the mutual actions of an irregular multitude of orbs. When discoursing of the results of such aggregations, Astronomy is virtually a branch of *Atomic* or *Molecular* inquiry; and with regard to the simplest problems concerning the association of Molecules, our dynamics are absolutely helpless. For instance, show me the geometer, who, through consideration of elementary forces, would undertake to be the architect of a crystal, or whose mathematical acuteness does not altogether quail in presence of that variety of determinate forms. These great stellar aggregations, too, are more complex than any crystal, inasmuch as their particles appear more mobile; but even putting that essential condition aside, I see no prospect of our easily arriving in this way at general expressions for the cause and manner of the stability of these singular groupings. If, indeed, that could be accomplished—if we could once

treat clearly of any complex cluster, considering it self-sustained and its form self-determined—then, the irregularities attached to it, and remaining unaccounted for, would belong to that order of *residual* phenomena which are always our sure finger-posts towards unexplored regions of truth. I think it likely, however, that long prior to an achievement, appearing at present to be very remote, observation will bring into light some circumstance, decisive at least as to the existence of external agencies. For instance, suppose these Spirals were found to be moving *en masse*,—suppose that idea confirmed, which almost irresistibly takes possession of one, on first looking at them—the idea, viz., that they are subject to a great motion of rotation around a central point—we should then conclude unhesitatingly that these masses are not self-determined, that they are part of a vast system—some grand succession of material forms, of which the aggregation of stars into clusters is only one phase,—these separate masses being its incidents. Stupendous, indeed, the conception; but why should it be startling? Simply because the views we are propounding call up spaces of time that cannot be measured, and giant acts transcending all with which man usually peoples that stage which he terms his universe—are these majestic intimations to be deemed incredible? Or shall we be stopped in our great course of thought, because it may be said by some one, *here* these marvels *began*—

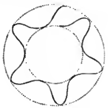
to this point you may ascend, but it is forbidden that you go further? I cast these things away, as fears and unworthy limitations of man, and take shelter within the freedom—the expanse of the behests of God. Placed by the Eternal in the midst of his gorgeous universe, with that unspeakable privilege of viewing Him as mirrored there through his high workings,—the Intelligence by which we interpret these workings has been stamped by Him who gave it with conditions which it must obey. But one of the most imperative of these conditions is, that we are bound—as by the inherent necessities of our being—to search for the explanation of every fact or phenomenon, through its relations with some actual order, present or past. Probably because man is so deeply immersed in the stream of change, that the faculty would be practically useless—no power is given to him by which he can recognise any event *as the necessary beginning of the series to which it belongs:* pierce far as it may, around his eye on every side lies the unfathomable. The effort to believe that we have reached a beginning, or, what is the same thing, to stake out a line beyond which—in some direction—intellect must in nowise pass, has indeed nowhere been uncommon: but the artificial barriers have always fallen; and in virtue of the prerogatives given it by God, Inquiry has disowned the restraint, and burst all bonds!

II.

Another consideration of profound interest and the most important consequences, arises not unnaturally from these general views. Whatever the cause or determining forces of these Nebulæ, can we suppose that their present shapes are *permanent*, or that each mass has reached its final condition?—a problem which, although most remote, may fortunately be treated with some degree of precision.

I. It was perhaps to be expected that the earliest speculations on this lofty subject should obtain as their foundation the idea of the *absolute permanency* of the existing forms of the stellar groups; the more especially as prior to the use of Lord ROSSE's great mirror, those shapes had frequently an aspect of singular simplicity, and therefore of apparent completeness. This manner of contemplating them, seems to have swayed Sir JOHN HERSCHEL when he endeavoured to determine the motions of which the stars of circular and oval clusters might partake, so that the shape of the group continue, and the relations of its orbs be restored after definite epochs. Taking the case of an oval group as including the circular form, he showed that if different stars start from a place of rest, and describe great ellipses around the centre of the figure in

one fixed period, the absolute stability of the cluster would be provided for, and that through all ages it might remain unaltered in form. A similar conception prevailed with M. Mosotti, who attempted to realize it in the case of annular groups, which—like that of Lyra, as previously known to us, (Fig. 1, Plate IX.,)—exhibit a simple and regular outline. The stars in such a ring would be permanently attached to the middle of the ring; so that any orb at one edge of it would move towards that line, its velocity increasing until it reached it; when—owing to that acquired velocity—it would cross the centre, and continue in motion until arriving at the ring's opposite edge, from which it would again return, and so continue oscillating for ever. Suppose now that the star had an *onward* motion also; then would its course be along the waving line below;—so



that the entire ring might continue with its existing proportions through any extent of duration. Similar modes of consideration might be applied to other nebular shapes; and they have at least one important significance;—they render palpable even to our im-

perfect appreciation of schemes of mechanism so immense and complex, how harmony may endure through very varied evolutions, and arrangements for order and stability — analogous to those, which, *within* our own unpretending planetary system, so greatly delight the eye. But in regard to their main aim—the demonstration, viz., of absolute permanence—they are not of importance; inasmuch as the *regular* forms of which they treat have no existence in nature. Sir JOHN HERSCHEL's idea might explain how a nebula like the upper figure in Plate V. could be endowed with perfect stability; but to clearer insight, that cluster appears as the irregular form below it. So also of MOSOTTI's annulus. The ring of LYRA, so simple and perfect in the field of a small telescope, is in reality the jagged and complex form of Fig. 1, Plate X. Nor do we find anywhere, that appearance of completeness or of geometrical simplicity among these Nebulæ, which alone could justify our supposing them, *final* results of pure dynamical laws. And besides, the notion of a steady cyclical recurrence of any class of phenomena, is not supported by adequate analogies. Around us there certainly lie on every side, stabilities of every order; but it is *stability* only that we see, not *absolute permanence:* for as our vision enlarges, every system that first appeared final and complete, invariably resolves itself into a step or phase of a still loftier progress. Look at our world as it wheels

around the sun, moving quietly along its courses of seasons, and unfolding as their accompaniments its succession of life and death. If aught of those larger appearances which are open to our close inspection, could appear stable, surely it is *that:* for as it rolls on, the sun shines on it, through every year the same, and affects it with the same varieties of light and heat. Yet note its interior history! No regular cycles are there, but a mysterious growth and evolution of races, insomuch that at different epochs our world has been fancied to have become new. Nor can its *orbit* even, be deemed permanent. It belongs to that part of our planetary system which has provision for the longest life. It is connected with that portion of it which seemed framed to rise above every perturbation, and to pass through the ages, stamped with capability for eternity; but suddenly a comet came with extraordinary tidings, informing us of an Ether, through whose persistent influence all such arrangements must close. Indeed, the absolute path of the car of being is everywhere along a complex curve, although definable through all its windings; while man, because his experience is drawn only from the smallest portion of its course, believes too often that the line is straight — seeing neither its anterior nor its posterior convolutions.

II. The illustrious founder of modern sidereal

SCALE OF LIGHT IN SPHERICAL NEBULÆ

astronomy, announced, half a century ago, the truth which I believe will be found the vivifying principle of all this department of inquiry. Looking attentively at the spherical clusters,—and of the shapes of the others he had no distinct knowledge,—he discerned among them, as we see now, a marked and regular progression in their essential features; and also a striking congruity among the non-essential, with the conclusion which the general aspect of these clusters induced him to accept. I have spoken already of the concentration of light and crowding of stars, around the central regions of such globular masses; and special occasions have required me to note the varying degrees of that condensation. But I must now request my reader's attention to these degrees, as constituting a *series* of appearances. Plate XIX. exhibits the scientific form of the gradation which really exists. None of the objects presented there has its counterpart in Nature; but in so far as the arrangement of light is concerned, each of these small spheres may safely be taken as the representative or *type* of a *numerous class* of stellar clusters. But besides the mere gradation, as manifested in this emphatic Plate, the irregular branches of these nebulæ — the *filaments* attached to them—all concur towards the result of our great Astronomer's thoughts. 'There are,' as he says himself, 'additional circumstances in the appearance of *extended* clusters which very much favour the idea of a

power lodged in the brightest part. Although the form of these be not globular, it is plainly to be seen that there is a tendency towards sphericity, by the *swell* of the dimensions, the nearer we draw towards the most luminous place, denoting, as it were, a *course* or *tide* of *stars* setting towards a centre. And if allegorical expressions may be allowed, it should seem as if the stars thus flocking towards the seat of power were stemmed by the crowd of those already assembled; and that, while some of them are successful in forcing their predecessors sideways out of their places, others are themselves obliged to take up lateral positions; while all of them seem eagerly to strive for a place in the central swelling and generating spherical figure.' The series is indeed so distinct, that if I would characterize the globular clusters we have resolved, and irrespective of all theory, I would simply refer them to one or other figure in Plate XIX. Their central compressions present a line quite unbroken, and were well illustrated by HERSCHEL, when he compared them to plants in different stages of progress, from juvenescence to proximate ripening or decay. It is not possible that these phenomena are mere delusions; nor are they to be explained by the mere existence of a '*power lodged in the brightest part.*' We are in presence of a solemn indication that, as with all things around us, there is here, too, the action of an evolving and transmuting cause.

III. On passing from consideration of spherical to that of the more complex nebulæ, the inquiry becomes much more arduous. In some respects, marks of a *series* may be found there also,—as, for instance, among the singular spirals; but it is always hazardous to infer regular progress from an apparent succession or connexion of forms, unless we have first, the distinctest apprehension of a *cause* of change—unless we are acquainted with a law or power which can effect transmutation, and therefore define its direction. For instance, with regard to these spirals, it is easy to see not only a gradation of forms, but the varying relationship of the forces probably producing them: it is impossible, however, in our present condition of knowledge, to say *in what direction* change might occur—whether by the farther opening of the arms of the spiral, or their closing in. But here, too, we meet with those irregularities of form, inexplicable by any law, which warrant the idea of *incompleteness*, or — what is the same thing—that no explanation of the object under review, can be drawn from its present state. Suppose them, however, as steps or phases in a grand series of changes, and the difficulty arising from their unformed state—their effort, as it were, towards some final and completed form, entirely disappears. If this is so, no marvel that their shapes appear capricious! We stand towards them as we would to our own earth, if the sum

of our perceptions regarding it were drawn from a glance during a momentary opening of the eye, which then shut again for ever. Shapes grotesque and wild, —tree, field, house, and mountain,—moving creature and naked rock,—in form unrelated, and juxtaposition everywhere inducing bewilderment,—such, in that case, would constitute our knowledge of a world instinct with fusing and enlarging harmonies. And thus, those strange spiral nebulæ, or our own irregular Milky Way, — nay, even the unfathomable mysteries of the spot in ORION, need confuse and startle us no more by the display of their sparse and unaccountable patches of stars. The mind ascending aloft, and passing from the idea of stability, may conceive now of all these forms, as partakers of a change as restless as the events which grow up, and fade, and pass away around it; and it darts through durations that have gone, and again towards the future, in eager but reverential effort to discern the nature of that SERIES or stupendous SUCCESSION which, through its own completeness, can bestow harmony and clear significance even on elements so perplexing and strange. And truly it is not in vain, or only for trifling objects, that we thus struggle to evoke, in all its attainable majesty, the IDEA OF TIME. The presence of these gigantic periods, replete with mighty works, is no mere phantasy to amuse, nor simply overpowering, like a heavy or affrighting dream. The

universe, stretched out along its co-ordinates — Space and Duration, calls forth, even as with trumpet-voice, the action of those faculties which alone can sustain man amid such immensities, by uniting him with the ABSOLUTE. By Faith we live now, even as the patriarchs: and Science, at the extremity of its evolutions, thus touches on a farther land, pointing across the frontiers of its flickering realms of change, to the calm but lustrous region of the Unchangeable.

III.

HERSCHEL adventured into a field of yet more daring speculation. Fixing on our Milky Way the penetrating glance of a reason which seldom quailed, and interpreting its *irregularities* by the principle which formerly guided him, he asked—Can a thing so void of all settled form, so wholly *capricious*, be supposed *stable?* Furthermore, on examining its different groups or cumuli, he saw that most of them are spherical, or approaching to the spherical form; and after specifying *two hundred and twenty-five* such groups in a limited extent of that zone, he concluded that there exists within it, operative over its fates—and indeed what, without exaggeration, may be termed its VITAL PRINCIPLE—an efficient *clustering power*, drawing its stars into separate groups, and whose irresistible power had *broken up the uniformity* of

the zone. My reader will recollect that when discussing the peculiarities of the great Spiral of Plate XII., I ventured to say that surely its branches had become so *discrete*, through the action of some such agent of change; and that if this were true, future alterations were—through the same influence—as clearly foreboded. And so, said HERSCHEL, casting his eye fearlessly towards future infinities, 'we may be certain that the stars in the Milky Way will be gradually compressed through successive stages of accumulation, until they come up to what may be called the ripening period of the globular cluster and total isolation; from which it is evident that the Milky Way must be forcibly broken up, and cease to be a stratum of scattered stars. . . . We may also,' he continues, in the same lofty mood, 'draw an important additional conclusion from the gradual dissolution of the Milky Way; for the state into which the incessant action of the clustering power has brought it, is a kind of chronometer, that may be used to measure the time of its past and present existence; and although we do not know the rate and the going of this mysterious chronometer, it is nevertheless certain that since a breaking up of the parts of the Milky Way affords a proof that it cannot last for ever, it equally bears witness that its past duration cannot be admitted to be infinite!' Surely the vision of these unfathomable changes—of the solemn march of the majestic heavens from phase to

phase, obediently fulfilling their awful destiny, will be lost on the heart of the adorer, unless when, beneath the canopy on which their annals are inscribed, it swells with that humility which is the best homage to the SUPREME!

Grounding on these sublime speculations, and taking into view some other facts, we are led to yet remoter conclusions. If the aggregation of stars in the Milky Way goes on—as it prognosticates—for ages; the clusters now, with some intermission forming its ring, will become isolated, and appear in the character of separate systems. But if this may happen in time future, *may not something similar have happened in time past?* And may not this be the meaning of those MAGELLANIC clouds in the south? May they not exhibit a multitude of stars and clusters formerly belonging to our system *in the very act of becoming isolated?* Reverting to those diagrams by which I attempted to give a rough or approximate view of the shape of one section of our great system, how irregular they are—how narrow in one direction, and how ragged their edges! Can it be possible that masses of stars have been torn away from those regions of our galaxy, which thus may indicate, by their comparatively small depth, that *there*, through the action of some irresistible cause, the galaxy has 'ripened' soonest? Singular to relate, it is precisely

at these thin sides that the smaller and nearer external nebulæ — globular and elliptical — are most crowded; *two thirds of the entire numbers known to exist being found in those localities.* In Plate XX. is a representation of the wing of VIRGO, a constellation situated near the shallowest part of our galaxy. How crowded with small groups—most of them, too, round and compressed! In the region opposite VIRGO, we have the same wonderful phenomenon; perhaps the only possible relic of that *former process of separation* of which the apparent breaking up of the Milky Way in our time may still be the prolongation!—If such views have any real foundation—if these separate firmaments show as emphatically as the groups in our present zone, the efficacy and march of a clustering power—may not ALL have come originally from one homogeneous stratum or mass of stars, so that their existing isolation, their separation and various groupings, are only the ongoings of the CLOCK—the gigantic steps of the hand by which TIME records the days of the years of the existing mechanism of the universe!

Stupendous, indeed, these conceptions; but down through their grandeurs there comes a gentle voice, reviving as a zephyr to the prostrate soul. In the vast heavens, as well as among phenomena around us, all things are in a state of change and PROGRESS: here too—

Plate LX

WING OF VIRGO

on the sky—in splendid hieroglyphics, the truth is inscribed, that the grandest forms of present being are only GERMS swelling and bursting with a life to come! And if the universal fabric is thus fixed and constructed, shall aught that it contains be unupheld by the same preserving law: is annihilation a possibility real or virtual—the stoppage of the career of any advancing being, while hospitable infinitude remains? No! let the night fall: it prepares a dawn when man's weariness shall have ceased, and his soul be refreshed and restored. To COME! To every creature these are words of hope spoken in organ tone: our hearts suggest them, and the stars repeat them, and through the Infinite, aspiration wings its way, rejoicingly as an eagle following the sun.

— Verily, it is an astonishing world! Change rising above change, cycle growing out of cycle in majestic procession—each new one ever widening, like the circles that wreathe from a spark of flame, enlarging as they ascend, finally to become lost in the empyrean! And if all that we see—if from earth to sun, and from sun to universal star-work—that wherein we best behold images of Eternity, Immortality, and GOD; if *that* is only a state or phase of a course of being, rolling onward evermore,—what must be the Creator, the Preserver, the Guide of all,—He at whose bidding these phantasms came from nothingness, and shall again disappear,—

whose name amid all things alone is, EXISTENCE — I AM IN THAT I AM!

The All-Encompasser: the All-Sustainer: He enwraps, he upholds, all those gorgeous heavens! Yea! unassisted, uncounselled, sustains He not—unchanged and unchangeably for evermore—even the fabric of His own Awful BEING!

Bending lowly before Him; humbly grateful that in the course of his beneficent arrangements he has permitted such intimations of his glory to reach us,—let us conclude in the rapt language of the PSALMIST,—

'HOW MANIFOLD, O GOD, ARE THY WORKS;
IN WISDOM THOU HAST MADE THEM ALL!'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